ASTM Bulletin

OCTOBER, 1952
No. 185

NOV 1952

NEWS—Actions on Standards; Publication Schedule; Technical Committee Work.

PAPERS—Arc Resistance; Efflorescence; Mechanical Properties of Gold Dental Alloys; Solving Problems in Materials.

American Society for Testing Materials

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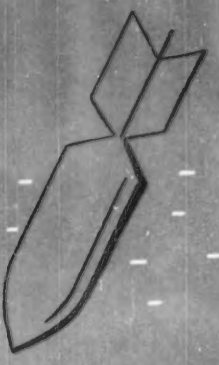

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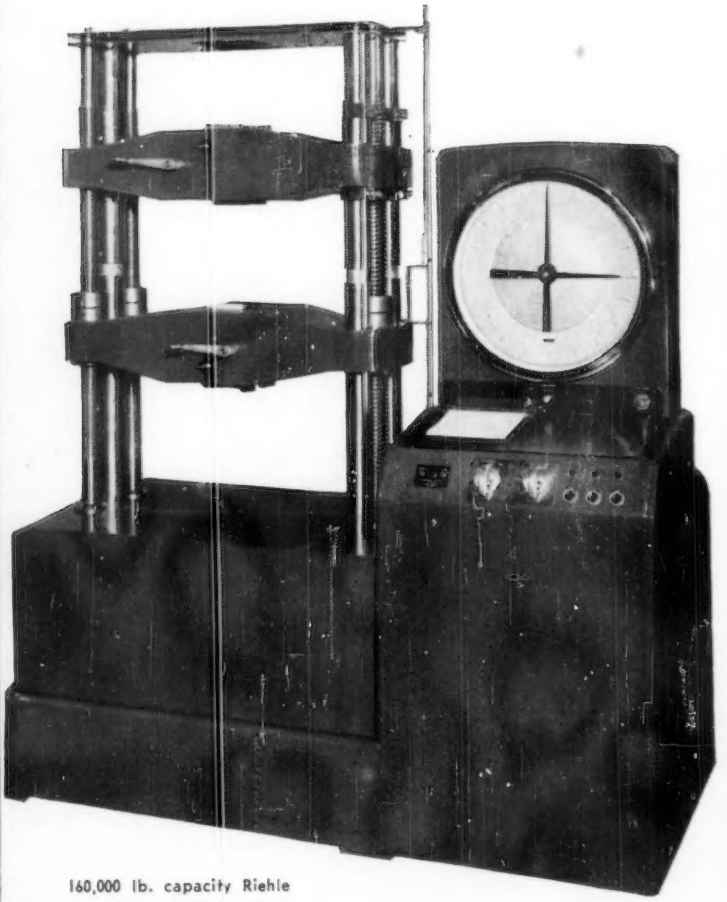

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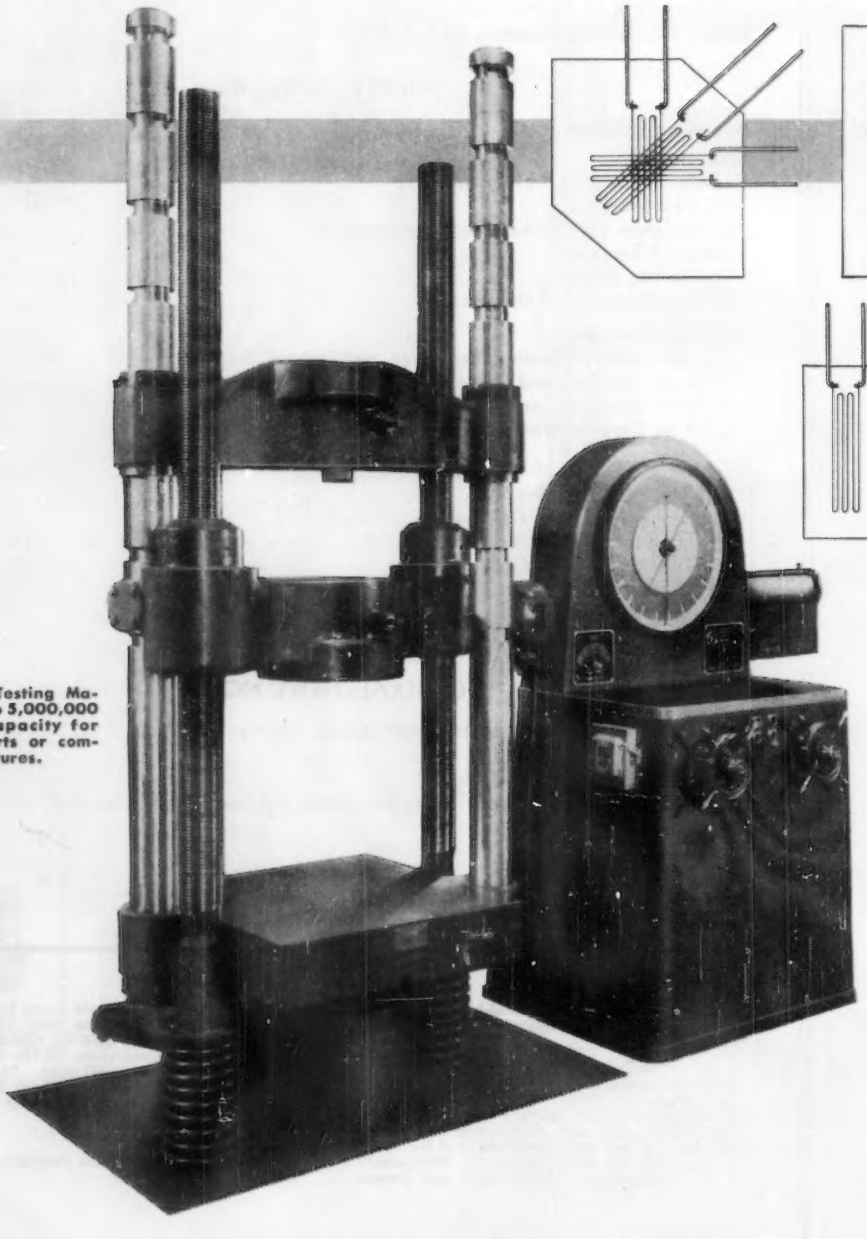

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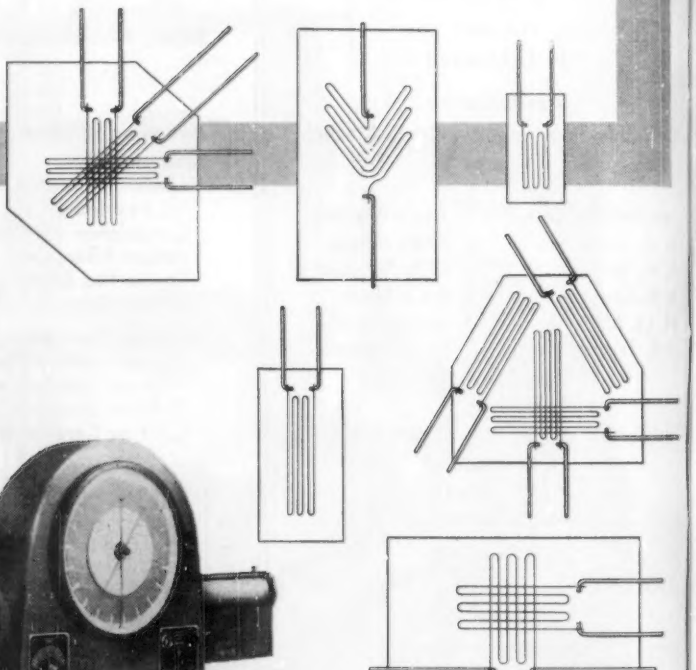

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ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering, and Standardization of Specifications and Methods of Testing"

Number 185 OCTOBER, 1952

Extensive Publication Schedule for 1952-1953

New Book of Standards, Special Compilations, and Fifteen Symposiums Highlight Unusually Large Program

THE publication schedule of the Society continues to grow as is evidenced by the number of publications listed below which cover a wide range of materials. As a result of the extensive program presented at the Fiftieth Anniversary meeting of the Society, and the scheduled appearance of the complete Book of ASTM Standards, there is an enormous amount of material to be published. More symposiums were presented at this than at any other Annual Meeting, and this will result in fifteen special technical publications. Twenty compilations of standards are listed for publication this year as well as many other special publications. The Staff and our printer are working to get this material in the hands of those interested at the very earliest possible time.

REGULAR PUBLICATIONS

1952 Book of Standards

The most important and certainly the biggest publication now in hand is the 1952 edition of the Book of ASTM Standards, which, as previously announced will be published in seven parts. This edition will total about 10,000 pages, an increase of about 20 per cent in size over the 1949 edition. Following previous practice, the seven volumes will be published as a grouping together of separate compilations. This year the books will be printed on Bible paper in order to cut down weight and size of the volumes. The seven parts are made up as follows:

Part 1—Ferrous Metals
Part 2—Non-Ferrous Metals
Part 3—Cementitious, Soils, Road and Waterproofing Materials
Part 4—Paint, Paint Materials, Naval Stores, Wood
Part 5—Fuels, Petroleum, Aromatic Hydrocarbons
Part 6—Electrical Insulating, Plastics, Rubber
Part 7—Textiles, Water, Soaps, Paper, Shipping Containers, Adhesives

An announcement concerning the office of Executive Secretary appears on page 21.

1952 Proceedings

The 1952 *Proceedings* (to be issued about February) will contain approximately 1200 pages. They include all reports and papers offered to the Society during the current year and accepted by the Administrative Committee on Papers and Publications for the *Proceedings*, together with discussion.

Most of the papers included are those presented at the 1952 Annual Meeting. The papers presented at the Annual Meeting as a part of special symposiums will for the most part appear separately as special technical publications. The table of contents and subject and author indexes cover all papers and reports published by the Society during the current year, which in addition to those appearing in the *Proceedings* include those accepted for publication in the ASTM BULLETIN or in Special Technical Publications.

1952 Index to ASTM Standards

This Index continues to increase in value as the number of standards becomes larger, and again it will give the latest complete reference to publications where the various specifications and test methods appear. The Index should be particularly helpful this year in view of the appearance of the 1952 Book of Standards in seven separate volumes. Publication of the new edition is scheduled for March, 1953, and will probably aggregate some 300 pages.

1952 Year Book

The Year Book, containing a list of the complete membership and official company-member representatives (name, title, address, company, etc.), and a list of geographical distribution of members as well as personnel of all ASTM committees, is furnished to members on request. The 1952 book became available this month and contains around 615 pages.

Special Compilations of Standards

The tabulation given below of special compilations of standards should be viewed as approximate only. There are so many factors affecting these books that it is not possible to give any accurate estimate of size or the date that they may become available. The size is affected by committee recommendations which may be submitted through the Administrative Committee on Standards, and the date of issue is governed somewhat by editorial consideration and the appearance of the Book of Standards, and also to a great extent by the tremendous load our printers are carrying.

SPECIAL TECHNICAL PUBLICATIONS, SYMPOSIUMS, ETC.

The following symposiums featured as part of the 1952 Annual Meeting, will be published separately with discussion.

1952 Annual Meeting Symposiums:

Tin
Paint
Fretting Corrosion
Recent Developments in the Evaluation of Natural Rubber
Testing Adhesives for Durability and Permanence

Sponsoring Committee	Title	Aproximate Number of Pages	Approximate Publication Date
A-1	Steel Piping Materials	384	November
B-1	Wire for Electrical Conductors	250	October
B-4	Electrical Heating, Resistance, and Related Alloys	225	February
B-5	Copper and Copper Alloys	516	January
B-7	Light Metals and Alloys	185	October
B-8	Electrodeposited Metallic Coatings	65	December
C-9, D-4	Mineral Aggregates, Concrete, and Nonbituminous Highway Materials	290	October
D-1	Paint, Varnish, Lacquer, and Related Products	804	October
D-2	Petroleum Products and Lubricants	820	November
D-3	Gaseous Fuels	160	December
D-4, D-8	Bituminous Constructional Materials	364	November
D-5	Coal and Coke	160	January
D-6	Paper and Paper Products	370	December
D-9	Electrical Insulating Materials	600	February
D-11	Rubber and Rubber-Like Materials	680	December
D-12	Soaps and Other Detergents	146	January
D-13	Textile Materials	656	October
D-14	Adhesives	96	December
D-20	Plastics	654	January

The Heaviest Publication Schedule of Any Period Confronts the Staff and Those Cooperating in Issuing Publications

Many members and committee members are participating in completing publications which will be outstanding. The schedule is an imposing one. Obviously, the special technical publications, with symposiums and numerous papers, are advancing that phase of ASTM work concerned with the promotion of the knowledge of materials. The big Book of Standards and the special compilations, several of which include much pertinent other data, in fact, are manuals in the real sense of that word. These reflect the concentration on the Society's second main objective, namely, standardization of specifications and tests. Members will be fully posted on the appearance of these publications and will be furnished with convenient blanks to procure them. On almost all, special prices to members are in effect.

Exchange Phenomena in Soils
Direct Shear Testing of Soils
Continuous Analysis of Industrial Water and Industrial Waste Water
Plastics Testing—Present and Future
Conditioning and Weathering
Determination of Elastic Constants
Light Microscopy
Effects of Notches and Metallurgical Changes on Strength and Ductility of Metals at Elevated Temperatures
Papers on Fatigue, with Emphasis on Statistical Approach
Non-Destructive Testing

Symposium on Tin

The modern tendency to buy and sell metals according to analysis rather than by brand name has not yet reached tin. In fact, it is the only major common metal not covered by specifications in this country. Now that there is a possibility of a free market for tin, and since about half the tin used in this country is produced (smelted) here, the advocates of a systematic classification for tin according to quality have been greatly encouraged.

Committee B-2 on Non-Ferrous Metals and Alloys has been asked to look into the feasibility and desirability of preparing specifications for this metal. The first step in this direction was the arrangement for a Symposium on Tin to obtain actual information concerning such problems as tin resources, production capabilities, conservation measures, fields of usage, and problems of analyses. Its purpose is to overcome some widespread misunderstandings concerning tin production problems and analytical difficulties, and to give information on some applications of tin and the effects of impurities. Also included in this volume is a panel discussion on methods of analysis. Summaries of the six papers comprising the symposium can be found in the May issue of the ASTM Bulletin. This book should be available early next year.

Symposium on Paint

At the Fiftieth Anniversary Meeting of the Society, ASTM Committee D-1 on Paint, Varnish, Lacquer and Related Materials held special observances of its own fiftieth anniversary. At this meeting a number of papers were presented reviewing the work of the individual subcommittees since their organization. There will be published in a special technical publication the reports of each major subcommittee concerned with materials and tests, giving an outline of background history and an idea of major accomplishments, particularly stressing unsolved problems, and a prediction, if at all feasible, about things to come. It will be of interest to note the study that has been put into the various test procedures over the years. In many cases accord has been reached with respect to specific test methods, whereas in other instances the conclusion was reached that the particular method under consideration did not lend itself to standardization. Copies of this publication will be available early next year.

Symposium on Fretting Corrosion

The phenomenon of fretting corrosion has been recognized for over two decades, but a partial understanding of its mechanism has been arrived at only in recent years. The investigation of fretting corrosion has necessarily included lubrication studies. Lubricating greases are widely used in antifriction bearings, and Technical Committee G on Lubricating Grease of Committee D-2 on Petroleum Products and Lubricants has a corresponding interest in fretting corrosion which prompted them to sponsor the symposium. Fretting corrosion has been defined as an oxidation of the mating surfaces of two parts when pressed closely together, as in a press fit or a tight bolted assembly where there is some relatively minute oscillatory motion between the two surfaces. The five papers cover present status of fretting wear, fretting corrosion tendencies of several combinations of materials, fretting corrosion in fitted members, effect of lubricants in minimizing fretting corrosion, and the mechanism of fretting corrosion. Summaries of the papers can be found in the May issue of the ASTM Bulletin. This book will be available next year.

Symposium on Recent Developments in the Evaluation of Natural Rubber

Since natural rubber has again become available in world markets, there has been a great need to improve and develop methods of physical and chemical testing of crude natural rubber. This has been the main objective of the subcommittee sponsoring this symposium, namely Subcommittee XII on Crude Natural Rubber of Committee D-11 on Rubber and Rubber-Like Materials. Wide variations have been found in curing rate and processing characteristics of natural rubber and in the amount of foreign material present, all of which is in marked contrast to the uniformity which has been obtained in the manufacture of synthetic rubber.

Eight papers are included in the symposium covering technical classification of crude natural rubber; Mooney viscosity measurements of technically classified rubbers; the nonrubber content and the measurement of cure rate of technically classified rubber; vulcanization characteristics of natural rubbers; quantitative procedures for the determination of dirt in crude natural rubbers; preparation of a standard natural rubber; aspects of the testing of natural rubber; and rubber evaluations with an Instron tester. Summaries of the papers can be found in the May issue of the ASTM Bulletin. This publication is scheduled to appear about the end of the year.

Symposium on Testing Adhesives for Durability and Permanence

One of the most important questions arising when fabrication with an adhesive is being considered is the durability or permanence of the adhesive, or how long the joint will last and how it will stand up in service. Many of the adhesives now being used have been developed within the past ten years, and consequently lack the background of many years of service typical of other materials of construction. Accelerated permanence tests are therefore of much importance and it was felt desirable, in the light of field experience, to review some of the tests that have been used. It is hoped correlation of field data and laboratory test data will eventually result in improved test methods for permanence in Committee D-14 on Adhesives.

The five papers in this symposium discuss specific as well as general applications and uses of simulated service and performance tests. Summaries of these papers were published in the May issue of the ASTM Bulletin. It is expected the book will be published early next year.

Symposium on Exchange Phenomena in Soils

Exchange phenomena in soils are critically important to the soils mechanics engineer and to the designer and construction engineer he serves, because exchangeable ions and molecules in clays determine to a significant degree the engineering performance of earth materials in foundations, slopes, and embankments. Like zeolites and some organic compounds, clay minerals adsorb ions and organic molecules from solutions and simultaneously release equivalent numbers of ions and molecules from their own substance. In nature, clay minerals of soils and geologic formations exchange ions and molecules continuously in response to changing concentration of dissolved solids in ground water. Similarly exchange can be effected artificially by surface applications, injection of solutions, or electrical treatments.

In this symposium sponsored by Committee D-18 on Soils for Engineering Purposes, exchange phenomena, or ion exchange reaction, are discussed from the standpoint of the necessity of understanding these phenomena in order to understand the nature of the properties of soils. Five papers, summaries of which appear in the May issue of the ASTM BULLETIN, cover various applications and experiences in connection with the subject. It is felt this symposium is a significant contribution to the engineering application of soil physico-chemistry, especially in its being a cooperative undertaking on the part of the applied scientist and the engineer. Copies of this publication will be available early next year.

Symposium on Direct Shear Testing of Soil

The desirability of a full discussion of the subject of direct shear testing of soils became apparent to Committee D-18 on Soils for Engineering Purposes when it became known that widely separated ideas as to the value of direct shear testing existed. Some have abandoned the test entirely, while others use it in the major portion of their investigations. The papers in the symposium are designed to cover as broad a range as possible, each discussing some phase of the subject, and thereby showing the usefulness or limitations of direct shear tests. It is felt that the papers and discussion included in the symposium are both interesting and valuable and should be most stimulating for further work in the entire field of shear testing of soils.

The six papers comprising the symposium cover the place of the direct shear test in soil mechanics, the many applications of direct shear tests in highway design, the use of such tests in earthwork projects under construction, the strength of gravel in direct shear, the use of the direct shear testing machine in foundation engineering practice, and a direct shear test with drainage control. Summaries of these six papers appear in the May issue of the ASTM BULLETIN. It is expected that copies of this symposium will be available the end of this year.

Symposium on Continuous Analysis of Industrial Water and Industrial Waste Water

The proper operation of industrial water and waste treatment plants requires control based on chemical analyses which must be made by laboratory personnel. With the increase in labor costs, emphasis is being placed on the use of automatic equipment for control and analytical determinations.

The Advisory Subcommittee of Committee D-19 on Industrial Water felt that a symposium on continuous analysis should be held and with this in mind a program was arranged to cover pH, oxidation, reduction potential, conductivity, alkalinity, acidity, chlorine residual, oil, hardness, turbidity, silica, and dissolved gases. The methods and problems inherent in the application of instrumentation to water control are given covering the various phases beginning with sampling and carrying through the actual analysis of dissolved constituents. In many cases, the final solution has not been evolved. However, the limitations and complexities of the problem have been well outlined and should be conducive to more rapid development in the future. To many, the application of these principles to the solution of their problems may be entirely new, but it should provide new horizons for an approach to their answer. This symposium will be of interest and value to many as it will show the part that instrumentation can play in providing better methods for solving analytical problems. Copies will be available early next year.

Symposium on Plastics Testing—Present and Future

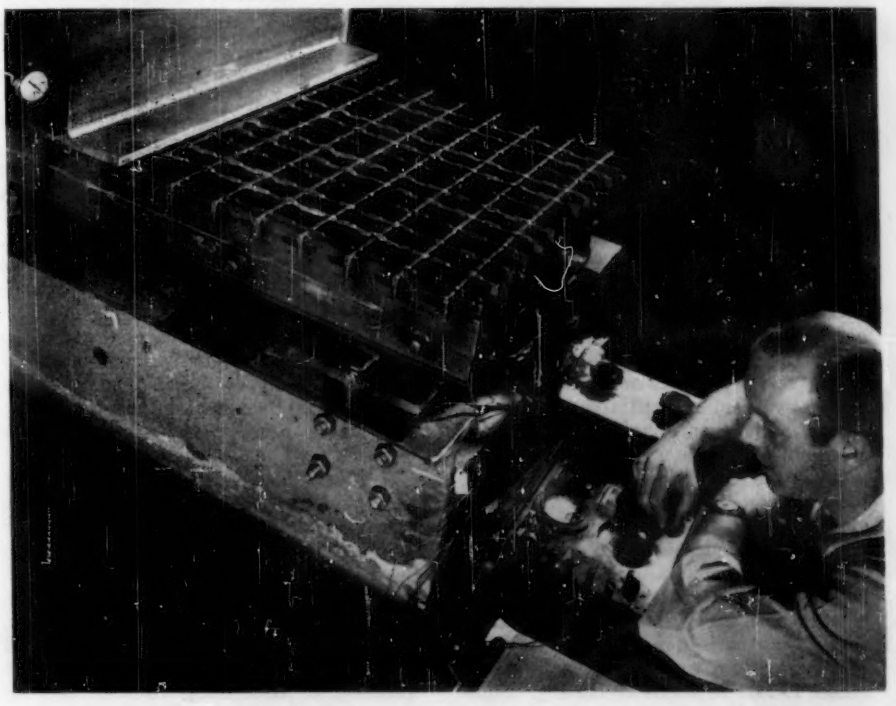
During any program of continuing effort, such as the activities of an ASTM working committee, it is useful to pause from time to time and re-examine the progress that has been made in order to find in what respects the efforts have borne fruit, and to what extent deficiencies still exist. Furthermore, it is often necessary to modify goals set earlier and to set new goals, in the light of additional theoretical and experimental knowledge which has been gained in the interim.

It is the dual purpose of this symposium to accomplish these ends, the first by describing from the ASTM viewpoint the present status of some of the tests for plastics, and the second by attempting to indicate the directions which future efforts at standardization may take if recent contributions to theories of behavior of high polymers are given recognition in our testing methods. The first four papers examine the situation with regard to mechanical, thermal, optical, and molding and permanence properties of plastics. The last three papers provide specific instances of current activities in the fields of accelerated exposure, rheology of thermoplastics, and examination of internal states of stress in cross-linked polymers. Summaries of the papers of this Committee D-20 sponsored symposium appear in the May issue of the ASTM BULLETIN. Copies of the book will be available the beginning of next year.

Symposium on Conditioning and Weathering

The technical need for temperature and humidity conditioning is well known. A wide variety of materials such as paper, adhesives, textiles, plastics, cement, electrical insulating materials, all require temperature and humidity conditioning prior to if not during testing. Industry recognizes this need by making large expenditures for equipment, enclosures, and even conditioned rooms and buildings. Outdoor and accelerated weathering tests are a must in practically all industries.

Committee E-1 on Methods of Testing felt that a symposium to review the fields of conditioning and weathering would be very worth while. The papers include a review of the historical background of conditioning and weathering in the various industries, present standard practices with particular reference to the whys and wherefores, and generalized discussion of major engineering effects of atmospheric influences. This up-to-date review of the whole field of conditioning and weathering is an important contribution and brings within the covers of one publication a re-



Deflection Tests on Steel Bridge Flooring Using Strain Gages

Second Prize, General Photographs, Eighth ASTM Photographic Exhibit, by Earl P. Morgan, United States Steel Co.

view of contemporary fundamental thinking in present conditioning and weathering practices. Summaries of these papers can be found in the May issue of the ASTM BULLETIN, and copies of the publication will be available early next year.

Symposium on Determination of Elastic Constants

A renewed interest in methods for determining elastic constants has developed with the rapidly increasing use of metals at elevated temperatures in engines of many types and the use of plastics and of composite materials in aircraft and other structures. In many of these cases adequate values of the elastic constants are not available in the literature and measurements must be resorted to. Various methods of measurement and their advantages and limitations are discussed in this symposium sponsored by Committee E-1 on Methods of Testing.

The five papers cover influence of temperature on the elastic moduli and Poisson's ratio of various commercial steels, methods for determining the elastic constants of nonmetallic materials, dynamic methods for determining elastic constants and their temperature variation in metals, an evaluation of several static and dynamic methods for determining elastic moduli, and report on ASTM task group for determination of elastic constants. Summaries of these papers appear in the May issue of the ASTM BULLETIN. The publication should be available in November.

Symposium on Light Microscopy

This symposium on light microscopy is broad and far reaching, each of the papers dealing with a specialized application of microscopy. It is introduced by a paper on the methods of microscopy which points out that technical microscopy involves more than apparatus and preparative techniques—it necessitates an extension of reasoning in terms of small-scale structures and processes. Another author describes two trends in apparatus development: first, the use of apparatus to widen the applicability of the microscope as a magnifying instrument; second, apparatus to extend the application of the microscope beyond its original purpose to qualitative and quantitative analysis of optical and other physical properties of small objects. The use of the light microscope in the evaluation of textile material, methods of polarized light microscopy as applied to the study of crystals, application of light microscopy in concrete research, microscopic examination of metallic specimens, microscopy of resins and plastics and particle size are covered in detail by authorities in these various fields. The symposium was sponsored by Committee E-1 on Methods of Testing. Summaries of each of the papers appear in the May issue of the ASTM BULLETIN, and it is expected that the book will be available the early part of next year.

Symposium on Effects of Metallurgical Changes on Strength and Ductility of Metals at Elevated Temperatures

In the past several years, considerable interest has developed regarding the effects of notches on metals at elevated temperatures, under either static or dynamic loading, and it is therefore appropriate that the Joint ASTM-ASME Committee on Effect of Temperature on the Properties of Metals should sponsor a symposium in which the results of current research are presented and discussed.

This symposium also deals with another aspect of the behavior of metals at elevated temperatures, namely, the metallurgical changes which occur during heating at elevated temperatures, and the effects of these on strength and ductility. It is believed that it will be of interest to many, particularly to those concerned with the many problems involved in supplying materials and designing and using them at the increasingly higher temperatures desired by the operator to improve the efficiency of his equipment. The metallurgist is hard put to furnish metals with the desired high-temperature properties. Symposiums such as this provide information from many sources and contribute to a free exchange of the valuable data that are being developed. The large number of papers presented testify to the metallurgist's desire to make maximum use of the inherent properties in a wide variety of alloys. Summaries of the eleven papers can be found in the May issue of the ASTM BULLETIN. It is expected that copies of this publication will be available by the end of this year.

Papers on Fatigue, with Emphasis on Statistical Approach

No single field of research has produced a more prolific flow of technical data than the study of fatigue. The growing trend of the past decade toward statistical analysis of test data has had a pronounced influence on the interpretation of these fatigue data, and ASTM Committee E-9 on Fatigue has been one of the first groups to take cognizance of the statistical aspects of fatigue. A Symposium on Statistical Aspects of Fatigue (published as STP No. 121) was presented at the Fifty-fourth Annual Meeting (1951). This year another session relating to the statistical analysis of fatigue data was held, and these papers are to be published as a special technical publication, "Fatigue with Emphasis on Statistical Approach."

One of the five papers includes the results of investigation on SAE 4340 steel gun tubes which showed that the variability of fatigue properties was greater than that usually estimated from the results of conventional nonstatistical testing procedures. The influence of metallurgical factors on the statistical behavior of fatigue properties is the basis of another paper. The problem of correlating conventional fatigue specimen data with actual service behavior has long been recognized and additional light is thrown on this problem in still a further paper which discusses rotating bending fatigue tests on carbon steel shafts up to 7 in. in diameter.

Any worker in the fatigue field regardless of previous statistical analysis experience will find these papers helpful and enlightening; they point out the definite need for a statistical approach to the interpretation of fatigue data. Summaries of the papers appear in the May issue of ASTM BULLETIN and it is expected copies of this book will be available the end of this year.

Symposium on Non-Destructive Testing

The great interest currently being shown by industry in non-destructive testing resulted in a symposium sponsored by Committee E-7 on Non-Destructive Testing. This symposium augments R. C. McMaster's 1952 Marburg Lecture on "Non-Destructive Testing."

The symposium is of an international nature including as it does papers from seven foreign countries. Various types of non-destructive tests as conducted in Denmark, England, Italy, France, Holland, Switzerland, and Germany are presented. In addition, a recent American development of extreme interest is covered in a paper on the development and use of immersed reflectoscopic inspection techniques on aircraft components. The work of Subcommittee II on Radiographic Standards for Steel Welds in preparing Standard Comparison Radiographs of Steel Welds is also included. This work, which required two years to assemble and classify, is of great immediate interest to the welding industry. This publication will be available early next year.

Marburg Lecture

The subject of this year's Marburg Lecture, the 26th in a distinguished series, was "Non-Destructive Testing" and was presented by R. C. McMaster, Battelle Memorial Institute.

Dr. McMaster emphasized the growing significance of this system of evaluating materials, referring to its tremendous significance in World War II when not only the science of industrial radiography, but the other non-destructive tests such as magnetic particle, ultrasonic, magnetic analysis, and others were used intensively to provide the armed services with sound materials and components. He outlines the significance of non-destructive testing, describes briefly the various methods that are available, and notes some of the economies resulting from the use of this method. Dr. McMaster's lecture is profusely illustrated and will be published later this year both as a separate publication and in the *Proceedings*.

Gillett Memorial Lecture

The First Gillett Memorial Lecture, entitled "Man, Metals, and Power" was presented by Norman L. Mochel, Manager, Metallurgical Engineering, Westinghouse Electric Corp. Because this was the first lecture to commemorate the late Dr. Gillett, Mr. Mochel devoted a considerable portion to biographical material covering

many of Dr. Gillett's chief interests, both technical and personal.

Since the Gillett lecture deals with the development, testing, evaluation or application of metals, Mr. Mochel in the technical portion of his lecture outlined the application of metals in the field of manufactured power, pointing out that our very existence and survival are dependent upon power development. In noting the widespread use of ASTM standards and other ASTM work in the field of power development he also pointed out that the first real central station turbine, a 1500-kw unit at Hartford, was in operation when ASTM was started in 1902. Many illustrations of power plants and parts showing the application of metals and other materials are included. Some of the metallurgical developments making possible the present high efficiency are cited, for example, steels which without liquid quenching have yield strengths of 100,000 psi with appropriate high-temperature properties.

Looking toward the future and the possibility of a 300,000-kw unit, he lists some of the progress made; for example, a temperature increase of 12 F per year; and a 1954 unit will require but 18 lb of structural steel per kw, whereas in 1945, 40 lb was needed. Many other significant facts are given, together with pertinent illustrations. This lecture will be issued in separate pamphlet form and will also be included in the *Proceedings*.

Symposium on Insulating Oil

The fourth of a series of symposiums on Electrical Insulating Oils, sponsored by Subcommittee IV on Liquid Insulation of Committee D-9 on Electrical Insulating Materials, will be published in November. The three previous symposiums were published in ASTM BULLETINS No. 146, May, 1947, pages 90 to 100; No. 149, December, 1947, pages 58 to 94; and Special Technical Publication No. 95. The first two symposiums are also available in separate pamphlet form.

This symposium is based on the results of the subcommittee's cooperative study on the correlation of laboratory tests with service performance of uninhibited insulating oils. This study was started about seven years ago with 19 different laboratories participating in the testing of periodic samples from 18 large power transformers in actual service. Oil samples for tests by all the cooperating laboratories were removed at about one-year intervals during normal operation by the different utility companies. To date voluminous data have been accumulated. The evaluation of the sludge test results with service performance of the oil in all the transformers as well as the correlation of the data of other tests with service performance has been recognized to be a very difficult and perplexing task and is the main purpose of this symposium.

Two papers with discussion comprise the symposium. One is based on the analysis of all the test results now available and presents the relative merits of the various laboratory tests studied. The other describes the condition of the transformers examined in an effort further to correlate the laboratory data obtained on the various oils tested with the actual condition of the transformers examined.

Symposium on Statistical Methods for the Detergent Laboratory

This symposium is evidence of the growing interest in statistical methods and their usefulness to the technical people of the soaps and detergents industry. The value of statistical methods is not that they lend a pseudo-scientific aura to technical papers and presentations but that they help in efficiently planning and performing an experiment and in getting the most knowledge at the least cost from the data obtained.

These papers describe the use of correlation, analysis of variance, tests for significance, and some ingenious graphical methods of statistical analysis. Of the five papers one deals with the design of laboratory control of laundry washrooms based on an analysis of variance. Another, on graphical methods of statistical analysis and tests for significance, presents a fresh approach to the problem of presenting data and one that ought to be used more often in the laboratory. Other papers deal with the importance of correlations in detergency testing, study of variability, and statistical analysis of a detergent efficiency experiment. Copies of this publication will be available early next year.

Symposium on Testing Metal Powders and Metal Powder Products

Because of the widespread interest in the testing of metal powders, Committee B-9 on Metal Powders and Metal Powder Products sponsored another Powder Metallurgy Symposium, the first having been held in 1943. While many symposiums have been held on the scientific and technical aspects of powder metallurgy, this is believed to be the first specifically concerned with methods of testing.

Powder metallurgy as a production method has made rapid progress during the past few years. New and improved methods for testing powders and fabricated parts are constantly being evolved. The symposium should serve as a medium of exchange of information for all who are interested in this field. Titles of the seven papers comprising the symposium are as follows: Quality Control of Metal Powder Gears; Methods and Devices for Testing Sintered Iron Rotating Bands; Porous Stainless Steel Compacts for Transpiration Cooling; Methods of Testing Cemented Carbide Compositions; Particle Size Determination in Metal Powders; Metal Powder Size Determination by the Roller Air Analyzer; and Some Experiences in Specific Surface Measurement by Low Temperature Gas Adsorption. Summaries of these papers can be found on page 18 of the April issue of the ASTM BULLETIN. Copies of this publication will be available the end of this year.

Metal Cleaning Bibliographical Abstracts (1842–1951)

These Bibliographical Abstracts are intended to make the published data on metal cleaning readily available to the many persons concerned with the production, finishing, and maintenance of metal products. This publication has been made possible by the intensive efforts of Jay C. Harris of Monsanto Chemical Co. in collecting, arranging, and indexing over 1000 annotated references to the literature on metal cleaning. It has become increasingly evident that the interest in metal cleaning is on the increase and that an up-to-date coverage of metal cleaning for all kinds of metal and by most types of processes is necessary. The material was first published in 1949 as Special Technical Publication No. 90. A supplement to this bibliography was issued in 1950 and, since that time, still further references have been collected. This new publication combines all of the references from the 1949 and 1950 editions in addition to several hundred new ones.

The material has been presented in what is believed to be the most useful manner. The references are arranged by year, and secondarily by author, or by the journal in which the article appeared if anonymous. The references are numbered consecutively. In order to facilitate reference to the abstracts they have been thoroughly indexed in the following four ways: Subject Index, Author Index, Specification Index, and Patent Index. This publication will be available in October.

Procedures for Emission Spectrochemical Analysis

Due to recent advances in emission spectroscopy, the variety of apparatus and techniques currently in use has become so large as to preclude standardization to the point that would enable the committee to write tentative methods. It was felt that the best approach to the problem was the collection of procedures that are currently being used. The committee has now completed the collection and preparation for publication of some 50 suggested methods for emission spectrochemical analysis, covering a wide range of materials and techniques. It is planned to publish these methods as a compilation which will be available around January.

Manual on Industrial Water

Committee D-19 on Industrial Water is preparing a Manual designed for use by executives, industrial water engineers, chemists, and plant operators. The following chapters will be included:

I. Uses of Industrial Water.
II. Difficulties Caused by Water in Industry.
III. Composition of Industrial Water Supplies and Water-Formed Deposits.
IV. Treatment of Industrial Water.
V. Sampling of Industrial Water.
VI. Analysis of Industrial Water.
VII. Sampling and Identification of Water-Formed Deposits.

VIII. Analysis of Water-Formed Deposits.
IX. Appendix.

The Manual will also include all of the ASTM standards and tentatives relating to industrial water. The inclusion of the methods in the Manual will supersede their publication as a separate compilation, for which there has been a considerable demand.

It is expected that the Manual will be available at the beginning of next year.

ASTM-IP Manual of Oil Measurement Tables

The Petroleum Measurement Tables being compiled jointly by the ASTM and the Institute of Petroleum (London) are now in the final stages of completion. It has been decided to publish the selected Tables in three volumes to meet the requirement of all countries, based on the following three approved systems of measurement: (1) U. S. System; (2) Imperial (British) System; and (3) Metric System. It is hoped that the U. S. and British volumes will be completed and made available before the end of the year. The computation work for the more than 500 pages of Tables which will comprise the three volumes has been done jointly but independently by the ASTM and IP, after agreement was reached on the basic formulas and data to be used. The volume of American Tables will be published and made available by the ASTM. The British and Metric volumes are being published by the IP.

Many Actions on Standards at Fall Meeting

THE Fall meeting of the Administrative Committee on Standards always is an important one since it provides an opportunity for many of the technical committees to request approval of new and revised specifications and tests in time for inclusion in the various books to appear during the year. This year the meeting on September 5 was particularly significant with a greater number of actions submitted than ever before. This was largely because of the pending publication of the 1952 Book of ASTM Standards in its new seven part division.

With several dozen new and revised standards approved, it is not feasible to detail all of the important technical angles, but the accompanying table does list all items approved. And the following article, arranged according to the fields covered, highlights some of the important new tentatives and revisions.

All of these new and revised specifications will appear in the 1952 Book of ASTM Standards on which the presses are now rolling, and some will appear prior to the publication of the big book in special compilations or separates. Other pages of this BULLETIN give information on the publication schedule.

Ferrous Metals

The structural steel and steel boiler plate specifications have been revised to raise the requirements for elongation in 2 in. Likewise, the various clauses in the specifications covering modifications in elongation for material under $\frac{5}{16}$ in. in thickness and over $\frac{3}{4}$ in. in thickness have been rearranged and revised. The rearrangement presents the modifications in a more readily understandable form. The revisions for the most part tighten the permissible modifications in elongation. Specifications affected by these revisions are as follows:

Steel for Bridge and Buildings (A 7)
Structural Silicon Steel (A 94)
Structural Steel for Locomotives and Cars (A 113)
Structural Steel for Ships (A 131)
Low-Alloy Structural Steel (A 242)
Low and Intermediate Tensile Strength Carbon-Steel Plates of Structural Quality (A 282)
Low and Intermediate Tensile Strength Carbon-Silicon Steel Plates of Structural Quality (A 284)
Structural Nickel Steel (A 8)
Boiler and Firebox Steel for Locomotives (A 30)
Open-Hearth Iron Plates of Flange Quality (A 129)
Carbon-Silicon Steel Plates of Intermediate Tensile Ranges for Fusion-Welded Boilers and Other Pressure Vessels (A 201)
Chromium-Manganese-Silicon (CMS) Alloy-Steel Plates for Boilers and Other Pressure Vessels (A 202)
Nickel-Steel Plates for Boilers and Other Pressure Vessels (A 203)
Molybdenum-Steel Plates for Boilers and Other Pressure Vessels (A 204)
High Tensile Strength Carbon-Silicon Steel Plates for Boilers and Other Pressure Vessels (A 212)
Manganese-Vanadium Steel Plates for Boilers and Other Pressure Vessels (A 225)
Low and Intermediate Tensile Strength Carbon-Steel Plates of Flange and Firebox Quality (A 285)
High Tensile Strength Carbon-Manganese-Silicon Steel Plates for Boilers and Other Pressure Vessels (A 299)
Chromium-Molybdenum Steel Plates for Boilers and Other Pressure Vessels (A 301)
Manganese-Molybdenum Steel Plates and Other Pressure Vessels (A 302)

Material furnished to the Tentative Specifications for Quenched-and-Tempered Steel Bolts and Studs with Suitable Nuts and Plain Washers (A 325) has become widely used in the structural steel industry. The specifications cover chemical and physical requirements of quenched-and-tempered bolts, studs, and similarly threaded parts 3 in. and under in diameter, usually made of medium carbon steel, for applications where high strength is required. The proposed revisions were recommended by structural engineers so that the specifications will be even more useful in this field.

Tentative Specifications for Carbon-Steel Blooms, Billets, and Slabs for Forgings (A 273) and for Alloy-Steel Blooms, Billets, and Slabs for Forgings (A 274) have been under review for the past two years. The present revisions bring these specifications into agreement with present industrial practice, particularly in regard to ladle and check chemical analysis ranges.

Corrosion of Iron and Steel:

A Tentative Specification for Zinc-Coated Steel Overhead Ground Wire Strand (A 363) was developed because of the need for such a product as specified by the Bureau of Reclamation and several utilities. The product differs from those in Specifications for Zinc-Coated Steel Wire Strand ("Galvanized" and Class A "Extra Galvanized") (A 122) and Zinc-Coated Steel Wire Strand (Class B and Class C Coatings) (A 218), primarily in the fact that no welds are permitted in the individual wires of the strand.

The Specifications cover two grades, High-Strength and Extra-High-Strength of concentric lay steel wire strand composed of seven wires with Class A, Class B, or Class C zinc coatings specifically intended for overhead ground wires or static wires for electric power transmission.

Specifications A 122 and A 218, mentioned above, are revised and reverted to tentative status on the basis of a modification resulting from the difficulty experienced by some manufacturers in meeting the length of lay requirements. The difficulty has been encountered in conforming to the minimum length of lay of 12 diameters when making preformed strand. The length of lay requirement does not constitute a major quality requirement and its elimination also eliminates the need for producers to request waivers.

Magnetic Properties:

The purpose of tentative revisions of Methods of Test for Alternating Current Core and Loss and Permeability of Magnetic Materials (A 343) is to recognize the smaller test specimens now being used by some producers and to encourage the saving of material by increasing the use of such specimens.

Iron-Chromium, Iron-Chromium-Nickel, and Related Alloys:

Requested by members of the industry, the Tentative Specifications for Iron-Chromium and Iron-Chromium-Nickel Alloy Tubular Centrifugal Castings for General Applications (A 362) cover iron-

Actions by the ASTM Administrative Committee on Standards, September 5, 1952

All actions listed below were taken on the above date except as noted

New Tentatives

Method of:

Test for Clay Pipe (C 301 – 52 T)
Bromide and Iodide Ions in Industrial Water (D 1246 – 52 T)
Examination of Water-Formed Deposits by Means of Chemical Microscopy (D 1245 – 52 T)
Cell Type Oven with Controlled Rates of Ventilation (E 95 – 52 T)
Sampling for the Testing of Cotton Fibers (D 1242 – 52 T)
Test for Fiber Weight per Unit Length and Maturity of Cotton Fibers (Array Method) (D 1243 – 52 T)
Test for Rosin Acids in Fatty Acids D 1240 – 52 T) (Approved Sept. 23, 1953)

Specifications for:

Iron-Chromium and Iron-Chromium-Nickel Alloy Tubular Centrifugal Castings for General Applications (A 362 – 52 T)
Zinc-Coated Steel Overhead Ground Wire Strand (A 363 – 52 T)
Brazing Filler Metal (B 260 – 52 T)
Materials for Soil-Aggregate Subbase, Base and Surface Courses (D 1241 – 52 T)
Laminated Asbestos Thermal Insulation for Pipes (C 299 – 52 T)
Cellular Asbestos Paper Thermal Insulation for Pipes (C 298 – 52 T)
Mineral Wool Pipe Insulation; Molded Type (Low Temperatures) (C 300 – 52 T)
Unorganic Aggregates for Use in Interior Plaster (C 35 – 52 T) (to replace existing Standard C 35 – 39)

Recommended Practice:

Designation of Yarn Construction (D 1244 – 52 T)
Radiographic Testing (E 94 – 52 T)

Tentative Revisions of Standards

Method of:

Test for Alternating Current Core Loss and Permeability of Magnetic Materials (A 343 – 49)
Test for Sieve Analysis of Wet Milled and Dry Milled Porcelain Enamel (C 285 – 51 T)
Testing Emulsified Asphalts (D 244 – 49)

Specifications for:

Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock (B 111 – 52)
Manganese Bronze Rod, Bar, and Shapes (B 138 – 52)
Masonry Cement (C 91 – 51)
Vitrified Clay Filter Block for Trickling Filters (C 159 – 51)

Definitions of:

Terms Relating to Structural Clay Tile (C 43 – 50)

Revisions of Standards and Reversion to Tentative

Method of:

Sampling Industrial Water (D 510 – 52 T)

Specifications for:

Zinc-Coated Steel Wire Strand ("Galvanized") and Class A ("Extra Galvanized") (A 122 – 52 T)
Zinc-Coated Steel Wire Strand (Class B and Class C Coatings) (A 218 – 52 T)

Revisions of Tentatives

Method of:

Testing and Standardization of Etched-Stem Liquid-in-Glass Thermometers (E 77 – 52 T)
Testing Cotton Fibers (D 414 – 49T)

Specifications for:

Steel for Bridges and Buildings (A 7 – 52 T)
Structural Silicon Steel (A 94 – 52 T)
Structural Steel for Locomotives and Cars (A 113 – 52 T)
Structural Steel for Ships (A 131 – 52 T)
Low-Alloy Structural Steel (A 242 – 52 T)
Low and Intermediate Tensile Strength Carbon-Steel Plates of Structural Quality (A 283 – 52 T)
Low and Intermediate Tensile Strength Carbon-Silicon Steel Plates of Structural Quality (A 284 – 52 T)
Structural Nickel Steel (A 8 – 52 T)
Boiler and Firebox Steel for Locomotives (A 30 – 52 T)
Open-Hearth Iron Plates of Flange Quality (A 129 – 52 T)
Carbon-Silicon Steel Plates of Intermediate Tensile Ranges for Fusion-Welded Boilers and Other Pressure Vessels (A 201 – 52 T)
Chromium-Manganese-Silicon (CMS) Alloy-Steel Plates for Boilers and Other Pressure Vessels (A 202 – 52 T)
Nickel-Steel Plates for Boilers and Other Pressure Vessels (A 203 – 52 T)
Molybdenum-Steel Plates for Boilers and Other Pressure Vessels (A 204 – 52 T)
High Tensile Strength Carbon-Silicon Steel Plates for Boilers and Other Pressure Vessels (A 212 – 52 T)
Manganese-Vanadium Steel Plates for Boilers and Other Pressure Vessels (A 225 – 52 T)
Low and Intermediate Tensile Strength Carbon-Steel Plates of Flange and Firebox Qualities (A 285 – 52 T)
High Tensile Strength Carbon-Manganese-Silicon Steel Plates for Boilers and Other Pressure Vessels (A 299 – 52 T)
Chromium-Molybdenum Steel Plates for Boilers and Other Pressure Vessels (A 301 – 52 T)
Manganese-Molybdenum Steel Plates for Boilers and Other Pressure Vessels (A 302 – 52 T)
Quenched and Tempered Steel Bolts and Studs with Suitable Nuts and Plain Washers (A 325 – 52 T)
Carbon-Steel Blooms, Billets and Slabs for Forgings (A 273 – 52 T)
Alloy-Steam Blooms, Billets and Slabs for Forgings (A 274 – 52 T)
Copper Rod, Bar and Shapes (B 133 – 51 T)
Rope-Lay-Stranded Copper Conductors Having Bunch-Stranded Members for Electrical Conductors (B 172 - 52 T) (Approved Aug. 1, 1952)
Rope-Lay-Stranded Copper Conductors Concentric-Stranded Members for Electrical Conductors (B 173 - 52 T) (Approved Aug. 1, 1951)
Bunch-Stranded Copper Conductors for Electrical Conductors (C 174-52 T) (Approved Aug. 1, 1952)
Air-Entraining Additions for Use in the Manufacture of Air-Entraining Portland Cement (C 226 – 52 T)
Mortar for Unit Masonry (C 270 – 52 T)
Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Units (C 126 – 50 T)
Structural Clay Facing Tile (C 212 – 52 T)
Chemical-Resistant Masonry Units (C 279 – 52 T)
Reagent Water (D 1193 – 52 T)

Recommended Practice for:

Boiling Nitric Acid Test for Corrosion-Resisting Steels (A 262 – 52 T)

chromium and iron-chromium-nickel alloy tubular castings 2 to 50 in. nominal outside diameter and 2 to 18 ft nominal length, made by the centrifugal casting process. The grades of alloys covered by the specification are those listed in the latest revisions of ASTM Specifications A 296 and A 297, referred to above.

Revisions in Tentative Recommended Practice for Boiling Nitric Acid Test for Corrosion-Resisting Steels (A 262) were recommended by Committee A-10 as a result of experience since 1944, to bring it into accord with present industrial practice.

Non-Ferrous Metals

Wires for Electrical Conductors:

Publication of Tentative Specifications for Standard Nominal Diameters and Cross-Sectional Areas of AWG Sizes of Solid Round Wires Used as Electrical Conductors (B 258 – 51 T) necessitated changing the numerical values for diameters and cross-sectional areas in the corresponding Committee B-1 specifications. Most of these revisions were approved by the Society at the 1952 Annual Meeting, but the revisions for B 172, B 173, and B 174 were inadvertently omitted in the preprinted report.

Copper and Copper Alloys:

Standard Specification for Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock (B 111) is tentatively revised to remove the allowance for 1 per cent tin in 80–20 copper-nickel alloy, since the alloy is no longer made with tin as an alloying element.

Standard Specifications for Manganese Bronze Rod, Bar, and Shapes (B 138) is tentatively revised in Section 8(*c*), "Shapes," to make a clear distinction between hot-forged rod and bar and rod and bar made by extrusion or hot rolling.

Committee B-5 also recommended revision of Tentative Specifications for Copper Rod, Bar, and Shapes (B 133) to include hardness and tensile requirements that are in closer accord with present commercial mill practice.

Filler Metal:

Tentative Specifications for Brazing Filler Metal were developed and submitted by the American Welding Society-American Society for Testing Materials Joint Committee on Filler Metal. The two grades covered by the Standard Specifications for Brazing Solder (B 64 – 43) have been incorporated with many other grades in the new specifications, so that Specifications B 64 have been withdrawn. The new specifications are intended to provide both the manufacturer and the user of brazing filler metal with a means of production control and bases of acceptance through mutually acceptable standard requirements.

Cement and Cementitious Materials

Cement:

Standard Specifications for Masonry Cement (C 91) cover two types of cement, with different strength requirements. Tentative revisions have been approved which will insure accurate and appropriate identification of the type.

Committee C-1 also recommended several revisions in Tentative Specifications for Air-Entraining Additions for Use in the Manufacture of Air-Entraining Portland Cement (C 226). These were worked out jointly with Committee C-9 on Concrete and Concrete Aggregates. The results of this cooperative study, a joint statement of policy and explanation of the ASTM procedure in the consideration of air-entraining additions appeared on page 24 of the September ASTM BULLETIN.

Clay Pipe:

Tentative Methods of Test for Clay Pipe (C 301) cover standard procedure for testing clay pipe for crushing strength, absorption and resistance to action of acids. These methods were developed in the committee to eliminate the duplication of the same tests in six different clay pipe specifications and to bring the latest methods of bearing tests to these specifications.

Lime and Gypsum:

Submitted jointly by Committee C-7 on Lime and Committee C-11 on Gypsum are Tentative Specifications for Inorganic Aggregates for Use in Interior Plaster to replace existing Specifications for Sand for Use in Plaster (C 35). These Specification outline limitations for those aggregates most commonly used in interior plaster, including perlite, sand (natural and manufactured), and vermiculite.

Mortars for Unit Masonry:

In the proposed revision of Tentative Specifications for Mortar for Unit Masonry (C 270), Committee C-12 has complied with requests to include a portland cement-masonry cement mixture in these Specifications. This addition has been made to Table II which gives mortar proportions by volume.

Manufactured Masonry Units:

Standard Definitions of Terms Relating to Structural Clay Tile (C 43) are revised to include the term "nominal dimension" which is being used more and more as the use of modular coordination in building design and construction spreads. To eliminate confusion with respect to this term it was felt this definition and others related to tile dimensions should be added to the standard.

Tentative revision of Standard Specifications for Vitrified Clay Filter Block for Trickling Filters (C 159) adds a typical glazing requirement for salt glazed products such as sewer pipe. The committee felt that the addition provides a reasonable glazing requirement in view of the difficulty in obtaining uniform glazed coverage in the production of this type of material.

Deletion of the "alternate crazing test" from Tentative Specifications for Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Units was recommended by the committee because the equipment called for necessitates maintenance and control of steam pressure by a hand manipulated control valve and bleeder valve. It was felt that too much reliance must be placed upon the so-called "human element" to make this a reliable comparative test procedure.

Proposed revisions of Tentative Specifications for Structural Clay Facing Tile (C 212) are intended to bring tolerances on distortion into line with those already approved for facing brick of similar quality. Minor changes are also made to clarify the specifications and remove the possibility of misinterpretation.

Revision of Tentative Specifications for Chemical-Resistant Masonry Units (C 279) was proposed to employ the use of the terms "H" and "L" to denote high absorption and low absorption respectively. The committee felt that these terms are more descriptive in a concise way than the terms "Standard" and "Minimum Absorption."

Thermal Insulating Materials:

Proposed Tentative Specifications for Laminated Asbestos Thermal Insulation for Pipes (C 299) cover preformed thermal insulation constructed of laminated asbestos felt or asbestos paper, in pipe-covering form, for use on pipes and tubing at temperatures up to 700 F.

Cellular asbestos paper pipe covering is used extensively with temperatures encountered in residential buildings and the proposed Tentative Specifications for Cellular Asbestos Paper Thermal Insulation for Pipes is intended to meet the need for a specification for this material. Specifically it covers preformed thermal insulation constructed of alternate layers of corrugated and flat asbestos paper, plied together in pipe insulation form, for use on pipes and tubing at temperatures up to 300 F.

For cold temperatures, industry has found mineral wool pipe insulation useful and both producers and consumers have requested a specification for the material. Tentative Specifications for Mineral Wool Pipe Insulation; Molded Type (Low Temperatures) (C 300), intended to meet this need, cover the composition, sizes, dimensions, and physical properties of this type of low-temperature pipe insulation.

Porcelain Enamel:

Committee C-22 has proposed revisions of Tentative Method of Test for Sieve Analysis of Wet Milled and Dry Milled Porcelain Enamel (C 285) to include a paragraph on Significance, and an alternative method. The latter, which is essentially the same test used practically exclusively for production control in the porcelain enamel industry, is an essential part of the tentative test method on screen analysis since it adds to the existing test method a procedure designed for production control for use in industry.

Miscellaneous Materials

Road and Paving Materials:

Standard Methods of Testing Emulsified Asphalts (D 244) are tentatively revised to include a method for the control of consistency of Type RS-2 emulsified asphalts as specified in Tentative Revision of Standard Specifications for Emulsified Asphalt (D 977).

Submitted jointly by Committee D-4 on Road and Paving Materials and D-18 on Soils for Engineering Purposes, are Tentative Specifications for Materials for Soil-Aggregate Subbase, Base and Surface Courses (D 1241) which were developed to put specifications for soil-aggregate highway materials on a more logical and systematic basis. When approved as standard it is intended to replace ASTM Tentative Specifications for Stabilized Base Course (D 556) and Stabilized Surface Course (D 557). The proposed specifications cover the quality and grading of sand-clay mixtures; gravel, stone, or slag screening; or sand, crusher-run coarse aggregate consisting of gravel, crushed stone, or slag combined with soil mortar or any combination of these materials for use in the construction of subbase, base, and surface courses. The requirements are intended to cover only materials having nominal or average specific gravity, absorption, and gradation characteristics.

Textiles:

Tentative General Methods of Testing Cotton Fibers (D 414) include separate procedures for testing the several properties of fibers. Committee D-13 plans to set up these individual methods of D 414 as separate standards. Revision of the sampling procedure is proposed in Tentative General Methods of Sampling for the Testing of Cotton Fibers (D 1242) which covers sampling procedures for determination of fiber length, length distribution, fineness, maturity, strength, cross-sectional features and nappiness of loose cotton fibers whether unprocessed or prepared from cotton products.

Tentative Method of Test for Fiber Weight per Unit Length and Maturity of Cotton Fibers (Array Method) (D 1243)

is a combination of the revised methods for fiber weight per unit length and for maturity. It is intended primarily as a research tool for determining the fiber weight per unit length, or maturity, or both, of a sample of loose cotton fibers, whether raw, processed, or obtained from cotton products.

Also proposed by Committee D-13 is a Tentative Recommended Practice for the Designation of Yarn Construction (D 1244) which describes the designation of yarn construction of single yarns, plied yarns, and cords. Modifications of the general practice as applicable to special cases are also included. This practice is a revision of a proposed practice published as Appendix V in the D-13 Compilation since 1941.

Naval Stores:

Proposed Tentative Methods of Test for Rosin Acids in Fatty Acids (D 1240) cover the determination of rosin acids in fatty acids when the rosin acid content does not exceed 15 per cent. In this method these acids are determined by titration after esterification of the fatty acids with methanol in the presence of sulfuric acid as a catalyst, followed by separation of the acids. Need for such a test has been felt for some time.

Industrial Water:

Two new test methods are proposed by Committee D-19: Tentative Method of Test for Iodine and Bromide Ions in Industrial Water which covers the titrimetric determination of iodide or bromide in the presence of chloride ions in industrial waste water, brine and sea water; and Tentative Method for the Examination of Water-Formed Deposits by Means of Chemical Microscopy. The procedures of chemical microscopy are applicable to all water-formed deposits, are less time consuming than chemical macro-analysis, and when supplemented by optical data, sufficient data may be obtained to make complete chemical analysis unnecessary.

The committee has also recommended revision of Tentative Specifications for Reagent Water (D 1193) providing for additional requirements concerning specific contaminants which may be included in the specifications by mutual agreement among the parties concerned.

Complete revision and expansion of Standard Method of Sampling Industrial Water (D 510) requires the reversion to tentative status of these methods covering the sampling at atmospheric or higher pressures, of industrial waters from all sources for physical, chemical, or biological tests.

Methods of Testing:

At the request of several committees for a standard type oven for laboratory tests, Committee E-1 has developed Tentative Specifications for Cell Type Oven with Controlled Rates of Ventilation which cover general requirements for equipment to determine loss in weight or changes in properties of materials on heating at elevated temperatures. This oven is recommended whenever the results are dependent on the time and temperature of heating, the amount of ventilation, or both.

The committee has also proposed Revision of Tentative Method of Testing and Standardization of Etched-Stem Liquid-in-Glass Thermometers (E 77). These changes based on three years' experience with methods are expected to clarify and facilitate their future use in standardizing and checking thermometers.

Non-Destructive Testing:

Proposed Tentative Recommended Practice for Radiographic Testing is intended to replace the former Methods E 15 which were withdrawn in 1947. This practice is intended as a concise guide to satisfactory radiographic practice rather than as a textbook.

NOTES ON PUBLICATIONS

New Bibliography and Abstracts on Electrical Contacts

Revised and Amplified Edition Covers 1835 to 1952; Available in November

THE Bibliography and Abstracts on Electrical Contracts, a revised and greatly expanded edition of the 1944 book contains a great deal of new material, bringing the total number of references to more than 1000 and hundreds of abstracts collected from 1835 to January 1, 1952. The intensive work on this publication was done by E. I. Shobert, Stackpole Carbon Co., for Committee B-4 on Electrical Heating, Resistance, and Related Alloys, and it is expected that supplements will be issued yearly to cover new references.

Such a bibliography must necessarily include references on a wide variety of subjects. The effects resulting from operation of electrical contacts are complicated, involving the microphysics of the electric arc, the metallurgy of the contact materials, the mechanics of the operating mechanism, the physical and chemical properties of the materials, and the ambient conditions. To be practical, however, such a bibliography must limit the information on widely scattered fields to what is pertinent to the problem involved. Decisions limiting the range of subject matter must be made carefully since the value of the work will be determined by the number of people it will serve. It has, therefore, been considered desirable to include any reference which appears to have any reasonable connection with the problems pertaining to electrical contacts.

This Bibliography is divided into several sections designed to make it most convenient for its users. The *Subject Index* groups the references according to various problems and details of the subject. The *Author Index* will be useful to those who wish to follow the work of a particular individual. The bibliography and abstract list is in chronological order and in some cases titles, which are complete, are given both in the original language and in English. Wherever possible, abstracts were taken from *Science Abstracts*, *Chemical Abstracts*, *Battelle Library Review* or similar publications. If not available there, abstracts were prepared by a member of the committee.

E. I. Shobert

Articles which touch upon many broad fields of contact application but are not specific in engineering and scientific details are included under the subject "Electric Contacts–General".

Bound in cloth, totalling 226 pages, the Bibliography can be obtained from ASTM Headquarters at $5.50 list price; to members, $4.25. A special order blank was sent recently to all members and committee members.

50-Year Index to Technical Papers and Reports

IN RESPONSE to persistent demand, ASTM has published a new comprehensive Index, listing under appropriate subject headings all ASTM papers and reports that have appeared in the *Proceedings*, ASTM BULLETIN, Special Compilations, Special Technical Publications, or as data appended to Committee Reports, from 1898 to 1950.

This Index includes certain innovations, for example, the author index which precedes the subject listings gives the complete titles of papers and items covered. This makes it possible to

present the subject index, by far the major portion of this publication, in a condensed and easily usable form. The subject index includes hundreds of headings, and every paper or report referenced is listed under the major subjects and materials discussed. The publication also gives a complete numerical listing of ASTM special technical publications (STP's). There is a condensed subject index listing of all the technical symposiums, those valuable groupings of technical papers which down through the years have provided technologists with a great wealth of information much of it reviewed and critically edited by technical committees or special committees of leaders in the various fields.

Essentially, the Index provides a much-needed key to the incalculable amount of information and data in the thousands of ASTM technical papers and reports which over a period of 50 years have preserved the best efforts of our leading technologists on the properties and testing of materials.

This highly condensed Index (about 230 pages in length) in convenient page size (6 by 9 in.) is now available for $6; members can procure copies for $4.75.

Let's Look at Our Methods

SCHEDULED to appear as part of the printed discussion of the *Symposium on Determination of Elastic Constants* which will be published this winter, are the following comments by T. McLean Jasper, Consulting Engineer, Milwaukee, Wis. In these remarks Mr. Jasper has sounded a precautionary note that would seem valid in all fields of materials testing.

"When we give values in the testing of materials we invariably give our measuring tools a clean bill of health and attribute to the material being tested the vagaries which we think we discover. Any other attitude would possibly reflect on our ability to construct or select measuring tools for the job in hand. If I could imply that in the selecting of tools for testing we should be particularly careful to look to our testing method, this might be of great benefit to us in arriving at the facts which should help us in the selection of materials. There is considerable difference between accuracy and sensitivity. Both are very essential when determining elastic moduli. Neither can be substituted for the other."

Joint Committee Compilation on Highway Materials Standards Issued

ASTM standard and tentative specifications, test methods, and definitions of terms pertaining to mineral aggregates, concrete, and nonbituminous highway materials are brought together under one cover in "ASTM Standards on Mineral Aggregates, Concrete, and Nonbituminous Highway Materials."

This revised compilation is sponsored by Committee C-9 on Concrete and Concrete Aggregates and Committee D-4 on Road and Paving Materials and includes all standards prepared under the jurisdiction of Committee C-9 and all standards pertaining to nonbituminous highway materials developed by Committee D-4. It also contains pertinent specifications for cement which have been prepared by Committee C-1 on Cement. A companion volume will be issued in November covering all materials of a bituminous nature used in highway construction and in the waterproofing and roofing fields.

This publication will be especially useful to producers and consumers of mineral aggregates, concrete, and nonbituminous highway materials, as well as to specifications writers, testing and inspection personnel, and to research and engineering institutions.

Copies of this 290-page book, bound in heavy paper cover, can be obtained from ASTM Headquarters, 1916 Race St , Philadelphia, Pa., at a list price of $2.75; price to members, $2.

References on Fatigue

THE second in a proposed annual series of "References on Fatigue" has recently become available. This is a multilithed list of references to articles published in 1951 dealing with fatigue. (A similar list in 1951 included 1950 references.) Brief abstracts of the articles have been included when these were readily available. Although the list is not exhaustive, the more than 160 references included should make it sufficiently extensive to be of interest to those concerned with this field.

References are arranged alphabetically, and eight references are included on each 8½ by 11-in. page. Each reference is self-contained in a ruled block. These equal divisions can then easily be cut apart and the references can be filed according to any desired plan.

If there is sufficient interest in a list such as this, similar references will be prepared annually. T. J. Dolan, Chairman, Survey Subcommittee of ASTM Committee E-9 on Fatigue, 321B Talbot Laboratory, University of Illinois, Urbana, Ill., has been responsible for the development of this service, and any comments or suggestions concerning the value and format of these lists should be directed to him.

Copies of "References on Fatigue" (STP No. 9-C) are available from ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa., at a price of $1.50. A limited number of references to articles published in 1950 (STP No. 9-B) are still available at the same price.

Knock Test Manual Appears in Newly Revised and Expanded Edition

THE revised and expanded second edition of the "ASTM Manual of Engine Test Methods for Rating Fuels," just off press, brings together under one cover the five standardized methods for making these engine tests which are used all over the world in the automotive and petroleum industries.

The five methods for determining the combustion characteristics of fuels, with their complete titles and ASTM designations, are as follows:

Method of Test for Knock Characteristics of Motor Fuels by the Motor Method (D 357)

Method of Test for Knock Characteristics of Motor Fuels by the Motor Method (D 908)

Tentative Method of Test for Knock Characteristics of Aviation Fuels by the Aviation Method (D 614)

Tentative Method of Test for Knock Characteristics of Aviation Fuels by the Supercharge Method (D 909)

Tentative Method of Test for Ignition Quality of Diesel Fuels by the Cetane Method (D 613)

Supplementary material covers details of the tests and latest information

on the best practices currently in use with respect to apparatus, reference materials and blending accessories, operation, maintenance, building and utility requirements, and installation and assembly. Also included is a discussion of the practical significance of fuel ratings obtained by these standard tests.

To this edition has been added a complete index covering methods and supplements which should greatly enhance its convenience and utility.

Charts and Tables:

In addition to the Manual itself which totals 342 pages, the Society will continue to issue as a convenience a number of the tables and charts which are required for recording test results. A list of the 13 tables which can be purchased separately can be obtained by writing Headquarters.

Three charts which are used in sizable quantities are available separately in the form of pads, 8½ by 11 in., of 50 sheets each. They cover: Reference Fuel Framework; Data Sheet for Supercharge Method; and Matched Temperature Line Chart for the Aviation Method.

This publication and all the material included in it has been prepared under the auspices of Research Division I on Combustion Characteristics of ASTM Committee D-2 on Petroleum Products and Lubricants.

Clothbound copies of the Engine Test Manual are priced at $6 to members; $8 list price.

Bibliography on Soil Dynamics

ONE of the interesting fields in the relatively new science of soil mechanics is that of soil dynamics. The great number of papers written on the subject are indicative of the interest in this phase of soil research and testing. Subcommittee R-9 on Dynamic Properties of Soils of Committee D-18 on Soils for Engineering Purposes has prepared an extensive List of Publications Referring to Soil Dynamics which was started in 1941 and now contains references up to and including the first part of 1952.

This bibliography is arranged in chronological order under the following headings: Seismic Methods; Seismic Investigations; Soil Vibrations Due to Traffic and Machines; and Dynamic Properties of Soils. Copies of this 10-page bibliography are available in mimeographed form from ASTM Headquarters at nominal cost of $1.

Resources for Freedom

Preparing for Future Policy

EDITOR'S NOTE.—Reprinted here in its entirety is the last chapter, Volume 1 from the five-volume report, "Resources for Freedom," of the President's Materials Policy Commission. This commission, headed by William S. Paley, has estimated future raw material needs of the U. S. and raised the question of how they will continue to be met. Some comments on the conclusions reached by the Commission were presented in the August, 1952, issue of the *Guaranty Survey*. A portion of that article follows this chapter.

The Continuing Task

ONE thing seems certain about the materials problem: it will persist. Its forms will alter; its severities may be controlled, and partial solutions will brightly present themselves—but the forces that brought the problem into being will increase rather than diminish. The central fact seems unalterable: as industrial civilizations grow in complexity they compound the demands made upon materials. This Commission does not accept the view that the world's increasing population pressures are catastrophic; it believes the reason Malthusian doom is so overdue is that Malthusian calculations have never given sufficient weight to the extraordinary ingenuity of mankind in extricating himself from situations before they become wholly and finally intolerable.

This Commission began its report with an expression of faith—faith in growth, in enterprise, in the future of freedom. It ends it with a reaffirmation: the materials problem may never be solved but it can be compensated. We will accomplish this, however, only if we recognize that as physical resources decline, the resources of ingenuity must rise up to serve mankind in their stead. It is a long, long reach from the charcoal fires that smelted Babylonian bronzes to the high-tension electric lines carrying scores of thousands of volts to wrest aluminum from bauxite—and every step along this road has been a step further away from what used to be "natural." There is no reason for thinking that the pots of the aluminum plant represent any more of a finality than a nineteenth century blacksmith shop. But greater and greater drafts of ingenuity will be called for in the future, to compensate for the slow failure of what used to be supplied us, more or less to our needs, by "nature." New societies, new economies—such as ours was two centuries ago—can perhaps afford the luxury of drifting. Established societies and economies have developed values we insist on preserving and so we are forced to take longer thoughts of the future. We are no longer vagrants on a continent, but established householders.

In this and other volumes of its Report, the Commission has attempted to outline the main features of the materials problem as seen from midcentury, and to find realistic answers to some of the questions it poses. The Commission believes that the policies and programs it has recommended will, if promptly and vigorously administered, do much to alleviate threatened shortages and to stimulate economic growth and promote free world security.

At the same time, the Commission is well aware that no single study by a temporary group can deal adequately with an immensely complicated situation cutting across the entire economy, persisting indefinitely, and changing from year to year. It was for this reason that, earlier in the Report, the Commission stated: "A task of such scope and complexity cannot be completed in one attempt. . . . The most important conclusion this Commission presents is . . . that the job must be carried on, cooperatively by Government and private citizens, not periodically at widely spaced intervals, but day by day and year by year."

Responsibility for surmounting materials difficulties and for carrying out a forward audit of foreseeable problems is shared widely among many industries, the universities and foundations, and many places in Federal, State, and local Governments. Each has its specific role to play. The Federal Government's task has been defined elsewhere (chapter 5, of this volume), and will not be reviewed here. This Commission has not undertaken to add to its larger task the responsibility for examining in detail the structure and functions of the Federal Government as they relate to materials policy and programs. The Hoover Commission in 1948 included activities concerning materials in its comprehensive studies and recommendations as the Commission on Organization of the Executive Branch of the Government. The Congress and the Bureau of the Budget have been considering these studies, and the Bureau of the Budget and other departments and agencies have developed still others. This work is of great importance and the findings of this Commission suggest the need for a high priority, particularly on the part of the Bureau of the Budget, for finding the answers to administrative and procedural questions raised by the materials problem.

Since the Commission has not undertaken to examine in detail the structure and functions of the Federal Government as they relate to materials policy and programs, it here concentrates on two problem areas of materials policy formation upon which it feels in a position to offer suggestions—collection and analysis of facts, and comprehensive appraisal of the whole materials situation.

Better Fact-Finding and Analysis

The importance of fact-gathering and analysis by Government agencies as the foundation of materials policies and programs has been recognized frequently in the course of this Report. Some of these findings were:

No Nation-wide census of minerals has been taken since 1939 (chapter 7).

Although both the Bureau of Mines and the Geological Survey develop some excellent data, they are not equipped between them to provide a comprehensive, current picture of the minerals situation in the free world or even in the United States (chapter 7).

No one agency of Government can offer a comprehensive picture of the pattern of federally financed technological activity relating to materials, much less to the whole field of technology (chapter 25). Even for one specific energy fuel —coal—the Commission found no adequate machinery for listing and appraising public and private projects of research and technological development (chapter 19).

There is no single source for a comprehensive appraisal of the Nation's long-range outlook for energy (chapter 22).

The Commission was somewhat encouraged to find that some agencies are identifying the materials problem and that industry is beginning to recognize that basic fact-gathering and analysis by Government can help industry determine useful lines of research and development work. But these are only beginnings.

Agencies responsible for fact-gathering and analysis in the materials field tend to concentrate on immediate problems at the expense of studying long-range situations that may become even more pressing if neglected. Even when agencies recognize the value of research and analysis this undramatic line of work often is the first to feel the axe of budget-cutting by Congress. The Commission can understand these tendencies, but the sober fact is that such neglect will cost the Nation heavily in the long run. A modest investment now in fact-finding and analysis, and in attention to the future, would pay large dividends in helping to spot problems in advance and in stimulating action to avert costly crises.

In the opinion of this Commission no type of activity is more essential to giving the taxpayer the most for his money in the long run. The Commission believes that analytical machinery in Government should be strengthened, from top to bottom, wherever materials problems are dealt with. The Commission already has recommended (chapter 7) that the Department of the Interior intensify its fact-gathering and analytical work in connection with minerals, and that sufficient funds be made available for a complete census of minerals industries in 1954 and every 5 years thereafter.

The Commission further recommends:

That each agency of the Government concerned with primary data on materials and energy strengthen its own fact-gathering, analytical, and programming machinery so that the Government's total efforts in this field will be adequate as a basis for estimating the total materials problem and that special attention be paid to the need for more and better economic analysis.

Steps Toward Correlating Policy

Not only is work in the different areas of the materials field imperfectly correlated, but there is a damaging lack of consistency even within distinct areas, as was developed earlier in this Report.

Domestic Resources.—The Commission concluded that there can be no purely domestic materials problems but only domestic aspects of world problems. Policies and programs affecting domestic production of minerals, for example, should be balanced with those concerning foreign development and imports and with others concerning technology in the use and substitution of materials. Programs concerning the various domestic resources should be better related, each with the other.

Foreign Resources.—The Commission recommended that a successor agency, or agencies, be created upon expiration of present emergency agencies to administer programs to help expand foreign production of materials needed by the United States. The Commission also recommended legislation to authorize elimination of import duties on needed materials for which the United States is, or might soon become, dependent upon imports. Effectiveness of these recommendations would depend

Engineering Leadership

. . . "Of all groups in our entire economy, none in their daily work and in their essential attitude to the accomplishment of their jobs, so completely refute these present-day politico-economic doctrines as does the engineer.

"Stand up and be counted now, if you are to lay any claim to the plaudits coming to our profession for its important place in our Centennial's depiction and celebration of our 100 years of engineered progress, and if you aspire to the hope of an extension of that progress through the engineer's continued creative and cooperative effort.

"We have talked of engineering leadership for years, but the time has come when the profession must replace talk by action. The high status which engineering should hold in the public mind will then be conferred on the profession. This will come to pass only when we have demonstrated the quality of leadership in engineering education and in public affairs of which our profession is so eminently capable.

"The hour is late, but not too late, if we will but do our essential part and if we will remember that great injunction of 1900 years ago, never more timely than it is today—'What does it profit a man if he gain the whole world but lose his own soul.' "

—*Carlton S. Proctor, President's Annual Address to the American Society of Civil Engineers, June, 1952.*

on adequate (and as yet nonexistent) machinery for accurately appraising the entire materials situation—the position of the United States in relation to that of the free world as a whole.

Energy.—The Commission recommended that a single Federal agency be designated to keep the entire energy situation and long-range outlook for all energy sources under review and that these activities should be closely coordinated with similar efforts in the formation of policy for all materials.

Technology.—The Commission recommended designation of a single agency to keep track of public and private research affecting production and use of materials in the light of current needs and future prospects, and to make sure that urgent research projects which industry could not be expected to undertake were referred to public or private organizations capable of carrying them out.

Security.—The Commission emphasized the need for relating emergency policies and programs, both short and long range, to the economy as a whole and for examining the probable effects of immediate programs upon longer range developments.

A single agency designated to keep all aspects of the materials problem under its eye should not, the Commission believes, be an operating agency. Its energies should be directed to broad, long-range analysis and not diverted into immediate problems of operation.

With access to all facts and analyses developed in various areas of the materials field, it could correlate this information and point out its deficiencies and gaps.

It could assess policies and programs in the light of assembled information and call attention to needs for new projects or for changes. It could keep abreast of significant activities among private agencies, including industry groups, universities, and the foundations, so that duplications by Government could be avoided, or conversely, so that any urgent and uncared for task could be signalled to attention. It could survey the total pattern of activities in the materials and energy field.

It should issue periodic reports to inform industry, the general public and the legislative as well as the executive branches of Government concerning leading developments in all the related materials fields.

To perform an assignment of such dimensions, the proposed reviewing agency would have to be high in the structure of the Federal Government, preferably part of the Executive Office of the President. It should be so placed because it would be informing operating agencies of the Government of needs for collecting new data and for analysis to serve new ends, and would have the essential task of indicating programs and tasks to various agencies. As an advisory body, framing recommendations for long-range policy, it would not duplicate the work of either permanent or emergency operating agencies. As a body primarily responsible for projecting the Nation's materials position as much as 25 years ahead, it would not duplicate the immediate and temporary coordinating functions of the Office of Defense Mobilization or the Defense Production Administration.

No existing agency fulfills all the requirements, but the National Security Resources Board appears most nearly qualified by present functions and past experience to undertake the responsibility.

It is an advisory rather than an operating agency, and it is situated within the Executive Office of the President. Under the National Security Act of 1947, its function is to advise the President on the coordination of military, industrial, and civilian mobilization, and many of its activities have therefore been concerned with materials.[1] Prior to the outbreak in Korea, N.S.R.B. had been organizing to perform many of the duties proposed here. The new emergency agencies created specifically to deal with mobilization drew upon plans already made by N.S.R.B. and early in 1951 absorbed a large part of its staff. At the time, these actions seemed a necessary expedient, but now that the emergency agencies are well established, N.S.R.B. should be in a position to rebuild and enlarge its long-range advisory service. To perform the task effectively, N.S.R.B. would have to recruit additional personnel of experience, judgment, flexibility, and constructive imagination and would need to be strengthened with additional funds.

N.S.R.B. appears to have the necessary statutory powers. Its authority to plan military support through economic mobilization necessarily comprehends the preparation and appraisal of policies to assure a strong resource base in peace or war. As the Commission has pointed out in chapter 27—

> Military security depends heavily on a vigorous and expanding economy to product the overwhelming quantities of the equipment, machinery, and supplies necessary for modern military strength. . . . Neither military nor economic strength can be raised to its highest

[1] Sec. 103 (c) of the National Security Act of 1947 (61 Stat. 499) provides:

It shall be the function of the Chairman of the Board to advise the President concerning the coordination of military, industrial, and civilian mobilization, including—

(1) policies concerning industrial and civilian mobilization in order to assure the most effective mobilization and maximum utilization of the Nation's manpower in the event of war;

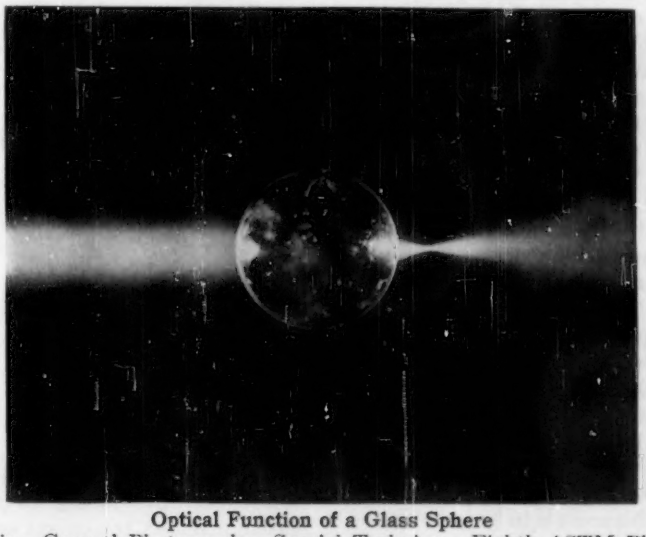
(2) programs for the effective use in time of war of the Nation's natural and industrial resources for military and civilian needs, for the maintenance and stabilization of the civilian economy in time of war, and for the adjustment of such economy to war needs and conditions;

(3) policies for unifying, in time of war, the activities of Federal agencies and departments engaged in or concerned with production, procurement, distribution, or transportation of military or civilian supplies, materials, and products;

(4) the relationship between potential supplies of, and potential requirements for, manpower, resources, and productive facilities in time of war;

(5) policies for establishing adequate reserves of strategic and critical material, and for the conservation of these reserves;

(6) the strategic relocation of industries, services, government, and economic activities, the continuous operation of which is essential to the Nation's security.



Optical Function of a Glass Sphere

Third Prize, General Photographs—Special Technique, Eighth ASTM Photographic Exhibit, by Allie C. Peed, Jr., Kentucky Department of Highways.

This photograph was made in a study of reflex-reflector paints and sheeting. Measurements made on this type photograph served to verify mathematically calculated relations of focal length to glass refractive index in the study of basic optical principles of reflex-reflectors.

potential without an abundant and varied flow of materials.

N.S.R.B. is already authorized, under the National Security Act of 1947, to utilize to the maximum extent the facilities and resources of the various departments and agencies of Government.

The Commission therefore recommends:

That the National Security Resources Board be directed, and provided with adequate funds, to collect in one place the facts, analyses, and program plans of other agencies on materials and energy problems and related technological and special security problems; to evaluate materials programs and policies in all these fields; to recommend appropriate action for the guidance of the President, the Congress, and the Executive agencies; and to report annually to the President on the long-term outlook for materials with emphasis on significant new problems that emerge, major changes in outlook, and modifications of policy or program that appear necessary. To the fullest extent consistent with national security, such reports should be made public.

The Materials Outlook and Free Enterprise[1]

Obstacles to Private Enterprise

THE commission has performed a valuable service also in stressing the need for intelligent conservation, for stimulating the discovery of new natural deposits, and for technological improvements leading to more efficient utilization. The real threat, it says, is not the threat of absolute shortages. "We need not expect that we will some day wake up to discover we have run out of materials and that economic activity has come to an end. The threat of the materials problem lies in insidiously rising costs which can undermine our rising standard of living, impair the dynamic quality of American capitalism, and weaken the economic foundations of national security. The central challenge of the materials problem is therefore to meet our expanding demands with expanding supplies while averting a rise in real costs per unit."

It is undeniable that, if a rise in costs is to be averted, the solution lies in conservation, new discovery, and improved technology. The commission, however, is not satisfied with these answers. "The real question," it says, "is whether capital, equipment, technology, and management skills will flow into the expansion of lowest-cost sources of supply in the less-developed countries at a rate sufficient to yield the necessary production. . . . The entire situation provides no basis for a complacent assumption that free-world countries will automatically produce enough to meet their increasing materials needs."

A partial answer to the commission's doubts on this score is to be found in the record of private enterprise. In the case of petroleum, for example, the far-sighted acquisition of foreign reserves by private corporations has done far more than furnish supplementary sources of oil for civilian needs in the United States. It has also done much to buttress the military strength of the "free world" in its efforts to provide safeguards against further Communist aggression. Similar foresighted action has been taken in steel, copper, and other basic industries.

If the investment of private capital in the development of new foreign resources has not proceeded faster, the reason lies largely in the obstacles placed in the way of such investment by political action. This is recognized by the commission, which reviews such factors as fears of expropriation, restrictions on currency conversion, export controls, nationalistic personnel and captial requirements, and unpredictable future political policies. To overcome such obstacles, the commission recommends the negotiation of investment treaties between the United States and countries with undeveloped resources.

Free Enterprise Needs Free Markets

In so far as governmental action tends to remove previously imposed restraints, it can be helpful. The commission, unfortunately, does not confine its recommendations to action of this kind. It proposes a set of devices to meet what it calls "the problem of materials market instability"—that is, in plain language, to manipulate prices, production, and exports by international agreement. "Multilateral contracts" on the model of the International Wheat Agreement would establish floor and ceiling prices. "Buffer stocks" would be bought and sold by a special international authority to offset natural fluctuations in supply and demand. "Quotas" or restrictions on production and exports would be used in conjunction with the "buffer stocks" to prevent long-continued downward trends in prices.

The whole history of domestic and international trade bears witness to the difficulties and perils that arise from well-meaning but misguided attempts at market manipulation. Almost every basic commodity entering into world trade has been the object of such attempts at one time or another. The record, it would seem, ought to be enough to discourage further experiments along the same line.

Price fluctuations can be troublesome. To some individuals and groups, they can be disastrous. Nevertheless, they have a function to perform, and that function cannot be effectively performed in any other way. The inconveniences that arise from price changes are insignificant by comparison with the evils that can result from price controls —the deep-seated economic maladjustments, the organized injustices, the international resentments and jealousies, the constant pressure to prevent the unwanted effects of existing controls by imposing new ones.

The President's commission fears that the uncertainty of earnings due to price changes is a deterrent to the development of new resources. It has not been so in the past—not until governments or private groups have undertaken to insist upon market "stability"—or market rigidity—as the price of cooperation.

If free competitive enterprise is made truly free and truly competitive, there need be no fear that it will fail to make available all the materials needed on an economical basis. It is generally the doctrinaire "social planner" who, ignoring the lessons of experience, argues that government can do it better.

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[1] This is a portion of an article, "The Materials Outlook and Free Enterprise," from the August, 1952, issue of the *Guaranty Survey*, reprinted with the permission of the Guaranty Trust Co. of New York.

Society Participation in Centennial of Engineering

THE Centennial of Engineering held in Chicago September 3 to 13 proved to be a quite colorful and interesting event in which thousands of engineers from all over the world participated. The centennial observed the 100th anniversary of the American Society of Civil Engineers. That society was joined by many others in making it a true observance of 100 years of engineering in general.

Materials have always played a most important part in all forms of engineering because it is only by means of materials that the ideas can be shaped and brought to life. Many developments in the engineering field went hand in hand with the development of adequate materials.

Centennial Luncheon and Dinner:

The high point of the centennial celebration was Wednesday, September 10, at a luncheon held in the Grand Ballroom of the Conrad Hilton Hotel. The official greetings were presented to the American Society of Civil Engineers and awards were made of the John Fritz Medal and of the Hoover Medal. Benjamin Franklin Fairless, President, United States Steel Corp., was the recipient of the John Fritz Medal; and the Rt. Hon. Clarence Decatur Howe, Minister of Trade and Commerce and Defense Production, Canada, received the Herbert Hoover Medal. Addresses were given by Messrs. Fairless and Howe and the Honorable Herbert Hoover.

The Society was officially represented at the Convocation by President Harold L. Maxwell.

In the evening of the same day, a dinner meeting was held at the International Auditorium with an address by C. F. Kettering, Director and Consultant, General Motors Corp.

Lecture by Norman L. Mochel:

The Society participated in the Centennial by sponsoring a lecture by Norman L. Mochel, Manager, Metallurgical Engineering, Westinghouse Electric Corp., who presented the first Gillett Memorial Lecture at the recent Annual Meeting. The title of the lecture was "Men, Materials, and the Power Industry, a Trio in Action." The session was held on Wednesday morning, September 10, and presided over by Past-President Morgan, Vice-President and Chief Engineer, Robert W. Hunt Co. Mr. Mochel covered some of the related factors of men and materials and their problems, and the power industry. It is proposed to include an abstract of the lecture in a future issue of the ASTM BULLETIN.

Session on Wood:

The Society joined with the American Society of Civil Engineers, the Wood Division of the American Society of Mechanical Engineers, and the American Railway Engineering Assn. in sponsoring a five-part Symposium on One Hundred Years of Engineering Progress with Wood. The session for which the ASTM was responsible was the first and was held at the Hotel Sherman on Thursday morning, September 11. The following papers were presented:

Wood as an Engineering Material—L. J. Markwardt, Assistant Director, U. S. Forest Products Laboratory, Madison, Wis. Chairman, ASTM Committee D-7.

Basic Principles of Structural Grading—Lyman W. Wood, Engineer, U. S. Forest Products Laboratory, Madison, Wis.

Working Stresses for Structural Lumber—R. P. A. Johnson, Chief, Division of Timber Mechanics, U. S. Forest Products Laboratory, Madison, Wis.

Commercial Lumber Grades—Frank J. Hanrahan, Chief Engineer, National Lumber Manufacturers' Assn., Washington, D. C.

Principles of Glued Laminated Lumber Design—A. D. Freas, Engineer, U. S. Forest Products Laboratory, Madison, Wis.

Past-President Markwardt served as chairman of this session. His very appropriate opening remarks are quoted in the accompanying box.

One Hundred Years of Engineering Progress with Wood

THE introductory remarks by L. J. Markwardt, chairman of the first session of the Centennial of Engineering Wood Symposium, were particularly apropos and in keeping with the spirit of the Centennial.

"With this Centennial of Engineering, we are again reminded that America, although still relatively young, is reaching a degree of maturity. Yet, I do not feel that we in America worship age as such in the sense that we have such reverence for aging structures that we fail to replace them when modernization is called for. We take pride in new developments and materials, and in being modern and up-to-date. I hope we will ever continue to do so.

"Sometimes, as we view on the far horizon a tiny cloud, we do not comprehend fully what it portends. Just so, when this Centennial of Engineering and the Wood Symposium was planned months ago, I do not think we fully sensed its significance. Now that it is upon us, we cannot fail to note that we are taking part in a great history-making event—the splendid attendance and programs at this Centennial are a great tribute to engineers and the engineering profession.

"How does it feel to be one hundred years old? Or who else than the 'Deacon,' in Oliver Wendell Holmes' classic poem, 'The Deacon's Masterpiece,' has designed a structure so accurately that it existed 'a hundred years to a day?'

"Oliver Wendell Holmes was a doctor, but I think we should give the genial Holmes credit as an engineer as well. Certainly his engineering philosophy was as simple as it was effective, and is worthy of emulation even in this day and age. Speaking of the one-horse carriage, he writes:

'It should be so built that it couldn' break daown,
Fur,' said the Deacon, 'it's mighty plain
Thut the weakes' place mus' stan' the strain;
'n' the way t' fix it, uz I maintain,
Is only jest,
T' make that place uz strong uz the rest.'

"And then as the fateful centennial of the Deacon's Masterpiece approached, he goes on:

'Little of all we value here,
Wakes on the morn of its hundredth year,
Without both feeling and looking queer;
In fact, there's nothing that keeps its youth,
So far as I know, but a tree and truth.'

"This brings us to the point where we can recognize trees as the oldest of living things, and wood as one of the oldest engineering materials. Yet, significantly, it maintains an indispensable place in the modern world. And significant, too, is the fact that in an age of diminishing resources, the forest is unique in that its proper harvesting is the best means possible of insuring a permanent forest resource. It is fitting that we here, today, take note of the significant progress with wood as an engineering material over the century."

ASTM Bulletin

OCTOBER 1952

NO. 185

NINETEEN-SIXTEEN
RACE STREET
PHILADELPHIA 3, PENNA.

Welfare Demands that Materials be Appreciated

ON AUGUST 13, the Chairman of the New England District Council —Dr. H. H. Lester, Physicist, Watertown Arsenal, and widely known in the Society and in fact throughout the world for his pioneering work in various fields, including radiographic testing—wrote a significant communication to Professor Herbert J. Ball, Lowell Textile Institute. A Past-President of the Society and long-time Chairman of Committee D-13, Professor Ball heads a committee in the New England Council on the promotion of ASTM activities and the stimulation of interest in materials' studies among the New England colleges and universities.

Dr. Lester pointed out that the New England Council must be actively pursuing some objectives and that a group that does nothing has no excuse for living. (The New England District has a fine record of accomplishment so its Chairman need have no fear on the score of activities but he, of course, wishes this to continue.)

We believe that many members will be interested in the meat of this letter and we reprint it with the writer's permission.

Perhaps some of our members and readers will care to comment on this general subject. The report of the President's Materials' Policy Commission, some recommendations from which appear elsewhere in this BULLETIN, and notes from a leading New York bank's publications are germane to this discussion.

"As YOU know the subject of 'Materials' has been a sort of hobby of mine. For the past three years about the most important objective of my own professional work has been the selling of the idea for a research center devoted to materials. This has been predicated upon the thesis that Materials are the primary necessity for the translation of human thought into concrete realization. They are the media by means of which mental concepts are made of practical usefulness for without them the design of a structure or mechanism that existed as a picture in the mind of a creative scientist or engineer could never be realized in actual practical existence. Nor can the realization go beyond the limits set upon it by the characteristics of the material such as strength, color, or what have you. In short, our civilized thinking and perhaps the evolution of civilization can go no further than the limitations imposed by the characteristics of the Material through which mental pictures are given concrete reality.

"Materials become then about the most fundamental considerations in this age of scientific achievement. ASTM is that Society which is most generally interested in materials. It should be recognized as one that is basically most important to our national welfare. Perhaps it is by some who appreciate the importance of materials, but as I have observed, it is not given the respect that is due by the majority of people who are rather inclined to magnify the achievements of chemists, physicists, engineers, etc., who conceive and build products of spectacular appeal because of functional possibilities. That is, they worship, as they should, the concrete expression of the mental picture of the constructive genius, and are less concerned with, or maybe totally unaware of the mechanisms that made the concrete expression possible.

"I am leading, in my devious way, to the point that the welfare of our national life demands that materials be appreciated and that they be improved. We can achieve these ends through ASTM. It could well be one particular mission of the New England District Council to needle the Society on this point. It could be that the New England District Council will lead the way toward practical accomplishment of this mission."

Schedule of ASTM Meetings

This gives the latest information available at ASTM Headquarters. Direct mail notices of all district and committee meetings customarily distributed by the officers of the respective groups should be the final source of information on dates and locations of meetings. This schedule does not attempt to list all meetings of smaller sections and subgroups.

DATE	GROUP	PLACE
October 27–29	C-16 on Thermal Insulating Materials	Hot Springs, Va.
October 27–29	D-20 on Plastics	Boston, Mass.
October 28	New England District	Cambridge, Mass.
October 28–29	C-9 on Concrete and Concrete Aggregates	Philadelphia, Pa.
October 29	C-17 on Asbestos-Cement Products	Philadelphia, Pa.
October 29	C-3 on Chemical Resistant Mortars	Philadelphia, Pa.
October 29–31	D-9 on Electrical Insulating Materials	Boston, Mass.
October 30	St. Louis District	St. Louis, Mo.
October 30–31	C-1 on Cement (50th Anniversary)	Philadelphia, Pa.
October 30–31	D-14 on Adhesives	Philadelphia, Pa.
November 12–14	B-8 on Electrodeposited Metallic Coatings	Philadelphia, Pa.
November 17–18	D-22 on Methods of Atmospheric Sampling and Analysis	Pittsburgh, Pa.
November 18	Southern California District	Los Angeles, Calif.
November 18–19	D-5 on Coal and Coke	Philadelphia, Pa.
November 25	Northern California District	San Francisco, Calif.
November 25	E-11 on Quality Control of Materials	Philadelphia, Pa.
December 4	C-20 on Acoustical Materials	Philadelphia, Pa.
1953		
January 26–28	D-19 on Industrial Water	St. Louis, Mo.
February 3–5	A-1 on Steel	Birmingham, Ala.
February 13	Philadelphia District (National Officer's Night	Philadelphia, Pa.
March 2–6	ASTM SPRING MEETING AND COMMITTEE WEEK	Detroit, Mich.
June 29–July 3	ASTM ANNUAL MEETING	Atlantic City, N. J.

Robert J. Painter Appointed Executive Secretary; Raymond E. Hess, Associate Executive Secretary and Editor-in-Chief

THE NEW EXECUTIVE SECRETARY was born in Ballston Spa, N. Y., but his family moved early to Endicott, N. Y., where he attended the public schools and high school. He was active in athletics in high school and at Rensselaer Polytechnic Institute where he received his degree of Civil Engineer in 1928. After a year's teaching at Rensselaer he became Assistant to the Special Engineer, Bethlehem Steel Co.

In February, 1931, he joined the ASTM Staff in Philadelphia when the offices were at the Engineers' Club. His early work with the Society included management of the exhibit of testing apparatus, developmental and promotional work, including membership, publication sales, and responsibility for contacts with the District Councils.

Mr. Painter was Technical Assistant and later Secretary of Committee A-1 on Steel, and he followed closely the work of the Joint ASTM-ASME Committee on Effect of Temperature.

Mr. Painter has devoted much time down through the years to the ASTM BULLETIN of which he had become Associate Editor and Business Manager.

On April 23 with the retirement of the long-time Treasurer, J. K. Rittenhouse, he was appointed Treasurer. It had been expected he would be assuming responsibilities for financial matters gradually, since Mr. Warwick was to continue his close supervision as he had for many years but the latter's untimely death quickly changed that situation. On top of these Headquarters problems there was the Fiftieth Anniversary Meeting where Mr. Painter was responsible for Staff Liaison with the New York Committee and directed a number of the special features.

In early October the Painters moved from suburban Philadelphia's Glenside to Ambler, Pa., where they are at home at 1225 Cedar Road.

To the ASTM Members:

A Special Committee of five officers was appointed at the May meeting of the Board of Directors by then President Fuller to study the Headquarters Staff organization and other available candidates with the view of making recommendations to the Board to fill the vacancy existing in the office of Executive Secretary.

Consideration was given to candidates in the staff, in the Society, and outside of the Society. The Committee, after earnest and thorough deliberations, recommended two promotions within the Headquarters Staff. These were approved by the Board of Directors in their Fall meeting on Sept. 16, 1952.

It is my pleasure to announce to the membership of ASTM:

MR. R. J. PAINTER, Executive Secretary

MR. R. E. HESS, Associate Executive Secretary and Editor-in-Chief

There are evidences on all sides of continuing growth in our Society; in the scope and quality of technical committee work; in the valuable assistance rendered to the several defense agencies and, in particular, the technical services provided by and for a growing membership, both here and abroad.

The officers of ASTM, speaking also for the technical committee representatives and the membership at large, affirm their confidence in the Headquarters Staff and its leadership in the years to come.

Sincerely,

Harold L. Maxwell

President

RAYMOND E. HESS joined the Staff of ASTM in February, 1920, following a brief time in the employ of Day and Zimmerman. A native Philadelphian, he graduated from Northeast High School in that city in 1915, and the University of Pennsylvania where he received his B.S. in Civil Engineering in 1919.

Shortly after coming with ASTM he was appointed Assistant Secretary, which title he carried until 1945 when he was appointed Assistant Executive Secretary, Technical Secretary, and Editor.

In addition to having direct responsibility for contacts with the various technical committees, Mr. Hess has given much attention to the work of the Administrative Committee on Standards, Administrative Committee on Simulated Service Testing, Administrative Committee on Ultimate Consumer Goods, and Administrative Committee on Papers and Publications. In addition he has over-all supervision of the Society's publications—the BULLETIN, Books of Standards, *Proceedings*, etc.

Mr. Hess has given much attention to contacts with other organizations, among them the American Standards Assn., where for many years he has served as alternate on Standards Council and on the seven correlating committees in which ASTM has an interest; he has also served as secretary for a number of the sectional committees, under ASA procedure, for which the Society is sponsor or joint sponsor. Mention should be made of the various contacts, established with foreign standardizing agencies, such as the British Standards Institution, South African Bureau of Standards, etc., which Mr. Hess has followed closely as well as the contacts with the International Organization for Standardization (ISO).

Mr. Hess resides at 8364 Fisher Rd. in Elkins Park, a suburb of Philadelphia.

A BRIEF NOTE TO OUR 7300 MEMBERS—

The Membership Committee Asks Your Cooperation in its aim to have the 50th Anniversary Year membership growth exceed that of last year.

This time is opportune—

1. for SUBMITTING NAME of that PROSPECTIVE MEMBER you've had in mind since last January (the 50th Anniversary Year will soon be gone). Send NOW to Headquarters the name of your engineering friend or business associate who would benefit by Society affiliation (convenient blank on p. 28).

   Our membership growth has been steadily maintained through the years. Every successive Membership Committee has recognized the invaluable aid of its *current members* in "preaching the gospel" of membership advantages to *prospective members.*

2. for SPONSORING that STUDENT MEMBERSHIP PRIZE AWARD you've been considering, but to date have omitted authorizing.

   Many of these Student Membership Prize Awards are being underwritten by ASTM members at their alma mater or other engineering school of their choice. OCTOBER is the appropriate month—schools are now in full swing—help acquaint these embryo engineers with ASTM and its work. Send your authorization TODAY to Headquarters ($2 covers the cost for one 1952–1953 Student Membership Prize Award).

Thank you
Membership Committee,
E. Ord Slater, *Chairman*
J. W. Bolton
D. K. Crampton
W. H. Lutz
M. A. Swayze

Offers of Papers for 1953

THE Administrative Committee on Papers and Publications will meet in early February to consider the papers to be published by the Society in 1953 and to develop the program for the Annual Meeting to be held in Atlantic City, June 29 to July 3.

All those who wish to offer papers for presentation at the meeting and publication by the Society should send these offers to Headquarters *not later than January 15, 1953.* All offers should be accompanied by a summary which will make clear the intended scope of the paper and will indicate features of the work that will, in the author's opinion, justify its publication and inclusion in the Annual Meeting program.

Suitable blanks for use in transmitting this information will be sent promptly upon request to Headquarters.

Why Am I an ASTM'er?

ASTM HEADQUARTERS files contain hundreds of letters embodying statements by our members on why they value ASTM. Many of these communications are copies of letters used by our members in following up membership invitations. Some of these, setting forth succinctly the reasons why men prominent in U. S. technology are in ASTM, have been used from time to time in the BULLETIN.

From a California Metallurgist—

...The ASTM has long been an authority in the matter of standards and of methods of testing and has done much to promote the knowledge of materials of engineering and their logical application. The benefits, both tangible and intangible, of membership are indeed worth while, and anyone engaged in either using or producing the materials of industry can gain thereby. For example, in your own field (castings, blast cleaning nozzles), there are active committees on ferrous and non-ferrous metals, with subcommittees for the various divisions of these groups. Two large volumes of standards for the ferrous and non-ferrous metals have been issued, as well as a separate publication on the chemical analysis of metals. There have been several standards on welding electrodes and similar materials.

We have an active Council in Southern California and the many local members take an enthusiastic part in the functions of the Society. We are sure you would enjoy the fellowship as well as the more practical aspects of membership....

Interesting District Meetings

New England—October 28; St. Louis—October 30; So. California—November 18; San Francisco—November 25

THE members and committee members in the respective districts where meetings are scheduled have received direct mail notices giving details of the sessions and events planned. This includes the New England, St. Louis, and California members.

New England—October 28—Plastics

The New England District took advantage of the meetings in Boston of ASTM Committees D-9 on Electrical Insulating Materials and D-20 on Plastics in planning its Fall Meeting. This takes place at the Hotel Commander in Cambridge on Tuesday, October 28. A dinner is scheduled at 6:30 p.m. with technical session following. The Chairman of Committee D-20, Dr. R. K. Witt, of Johns Hopkins University, Baltimore, Md., will speak and Dr. Gordon M. Kline, Assistant Chief of the Division of Organic and Fibrous Materials, National Bureau of Standards and former chairman of Committee D-20, will have just returned from Europe and will give a report on plastics developments there. Both men are outstanding authorities and excellent speakers. In addition, all of the New England members and members of Committees D-9 and D-20 have been invited. Dinner reservations should be sent to C. G. Lutts, Boston Naval Shipyard, Bldg. 34, Boston 29, Mass. Daniel Cushing, Consulting Metallurgical Engineer, has arranged the program in close cooperation with Messrs. Lester, Lutts, and Chadbourn, the District Officers.

St. Louis—October 30—Chemical Developments and Engineering Materials

President H. L. Maxwell will address his second District Meeting when he speaks at a joint meeting of the St. Louis members of the Society and the Engineers' Club of St. Louis in the latter's building on October 30. The Society's President who is Supervisor of Mechanical Engineering Consultants, E. I. Du Pont De Nemours & Co., Inc., will cover "Chemical Developments and Engineering Materials," presenting some of the interesting aspects of materials problems encountered in putting new chemical processes into producing plants.

California Meetings

Dr. R. C. McMaster, Battelle Memorial Institute, and President of the Society for Non-Destructive Testing, will be the chief technical speaker at joint meetings in Southern and Northern California of ASTM members with the local chapters of the Society of Non-Destructive Testing. The Los Angeles Meeting, Rodger Young Auditorium, is scheduled for Tuesday, November 18, and the Northern California session in San Francisco is on November 25, St. Julian's Restaurant. Through the close cooperation of Battelle Memorial Institute Dr. McMaster was able to accept the invitation from the

ASTM California groups to deliver a version of his notable Edgar Marburg Lecture on Non-Destructive Testing and as the new president of the NSTA it was fitting that the meeting there should be joined with those local chapters.

NOTE.—ASTM Executive Secretary, R. J. Painter, will attend the California Meetings and will be with Dr. Maxwell in St. Louis. On his way to the coast he is having a dinner meeting with some of the active members and committee members in the Houston area to explore the possibility of establishing a new district in Texas.

Other District Activities:

Several of the other districts including New York, Washington, and Philadelphia, have meetings scheduled and further details will be given in direct mail notices to the members. All members and committee members of the Society are cordially invited to attend these meetings. Frequently members from far distant points may be in a locality where the meeting is being held and the local men are glad to welcome them.

As this BULLETIN is readied for press, meetings of the Pittsburgh and Philadelphia Districts are being held. News accounts will appear in the December issue.

The 1953 Nominating Committee

IN ACCORDANCE with the By-laws providing that the Board of Directors shall select a nominating committee for officers, the Board has considered the report of the tellers—W. C. Clements and G. H. Mains—on the recommendation of members for appointees on the nominating committee and alternates, and has appointed the following:

Nominating Committee

Members

C. L. Kent, Jones & Laughlin Steel Corp.
R. R. Litehiser, Ohio State Highway Testing and Research Laboratory
R. E. Davis, University of California
W. R. Willets, Titanium Pigment Corp.
J. C. Geniesse, Atlantic Refining Co.
G. H. Hotte, A. M. Tenney Associates, Inc.

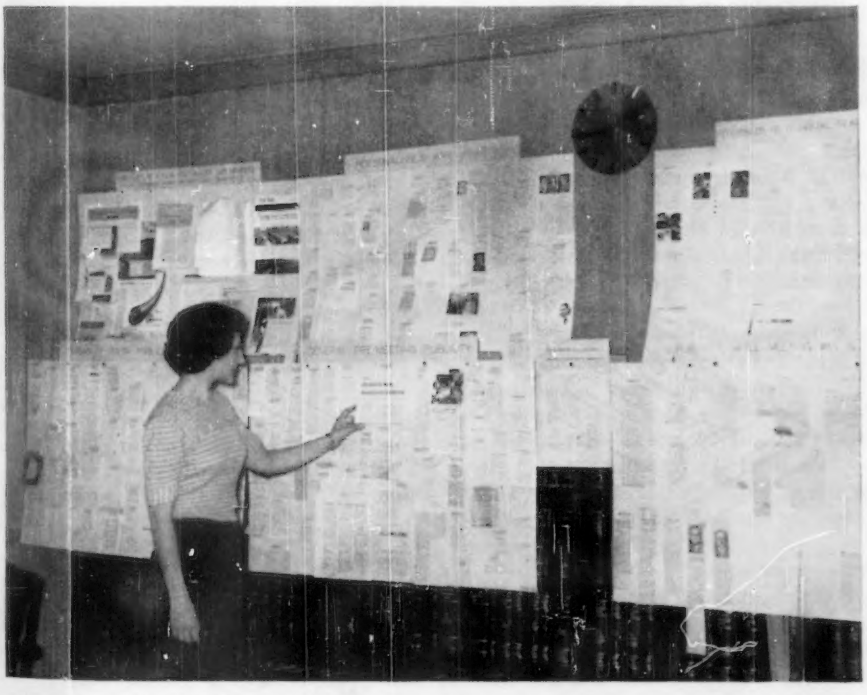
Respective Alternates

H. C. Larson, Bethlehem Steel Co.
C. E. Proudley, North Carolina State Highway and Public Works Commission
S. H. Graf, Oregon State College
G. M. Kline, National Bureau of Standards
L. C. Burroughs, Shell Oil Co., Inc.
A. G. Ashcroft, Alexander Smith, Inc.

Serving on the 1953 Nominating Committee as *ex officio* members are the three immediate past-presidents: J. G. Morrow, L. J. Markwardt, and T. S. Fuller. The committee will meet sometime in March and will nominate for each office—president, vice-president, and five members of the Board of Directors. The selection by the Nominating Committee will be announced to the members in the ASTM BULLETIN prior to transmission of the official ballots.

Symposium on Techniques for Electron Metallography

A Symposium on Techniques for Electron Metallography will be held under the auspices of ASTM during the June, 1953, meeting in Atlantic City. The program is being organized by Subcommittee XI on Electron Microstructure of Steel of Committee E-4 on Metallography. The objective is to present discussions of current techniques employed in the application of electron microscopy to metallurgical research. Contributions are solicited by the program committee. Titles and abstracts should be submitted to the Program Chairman, C. M. Schwartz, Battelle Memorial Institute, Columbus 1, Ohio.



At its regular September Meeting, the ASTM Board of Directors was given the opportunity of reviewing in the display pictured above the results of the extensive publicity campaign carried through for the 50th Anniversary Meeting. Separate panels were devoted to clippings on subjects as Awards and Honors, Personalities, Technical Program, Pre- and Post-Meeting Publicity, etc. The small sheet under the clock listed the 200 leading trade and technical publications, and house organs from which the clippings were gleaned.

All Items on Standards Ballot Approved

THE canvass of the results of the 1952 letter ballot shows that the membership of the Society has approved all the items listed on the ballot. This included 1 adoption of a new standard, 134 revisions of existing standards, and 87 adoptions of tentatives as standards.

Details concerning these actions were given in the Summary of Proceedings of the Fifty-fifth Annual Meeting, which was mailed to all members in September, together with the letter ballots. The details will also be published in the 1952 Book of ASTM Standards, the first part of which is scheduled to appear very shortly.

Proposed Method of Test for Erasing Quality of Paper

EDITOR'S NOTE.—This proposed method has been prepared by Subcommittee I on Paper Testing Methods of ASTM Committee D-6 on Paper and Paper Products, under the chairmanship of R. H. Lace, Ditto, Inc. This method is being published as information only in order to solicit comments preliminary to further consideration for adoption by the Society. Comments should be addressed to the Society, 1916 Race St., Philadelphia, Pa.

Scope:

1. This method is based on the controlled abrading procedure of Codwise[1] and Lafontaine and employs the rubbing action of an abrasive cloth applied under standardized conditions in a mechanical abrading apparatus. It is applicable to various types of paper surfaces and although the method covers the erasure of standardized ink markings, the principle described can be employed to advantage for all types of erasure work.

Definition:

2. Erasing quality is defined for the purpose of this test as the difficulty of erasure with a mechanical abrading apparatus of standardized marks made with standard writing ink, on the surface of the paper in question. The apparatus employs the rubbing action of No. 180 Silicon Carbide Cloth. The difficulty of erasure is measured numerically and observations are made of the resistance to fuzzing of the surface of the paper as well as for the writing qualities of the erased surface.

Apparatus:

3. The apparatus shall consist of the following:

(*a*) *Abrading Machine.*—This shall be of the general type shown in Fig. 1 which shall comprise the following essential features:

(*1*) A movable abrading head assembly having an effective weight of 330 g. It is necessary that this have a carefully controlled abrading action and that the weight of 330 g be exerted during the entire stroke of the head.

(*2*) Means for moving the abrading head across the surface of the specimen at a rate of 120 single 2-in. strokes per min.

(*3*) Provision in the abrading head to accommodate an abrading medium 1-in. long, $\frac{3}{8}$ in. wide and to hold it firmly in place.

(*4*) Provision for clamping the paper specimen on a metal plate 5 in. in diameter, covered by a stable rubber apron cloth as described in paragraph 3(*e*).

(*b*) *Ruling Pen.*—A ruling pen of standard quality with adjustment capable of giving an opening between the nibs of 0.001 in. (The opening may be checked by means of a 0.001-in. thick sheet of material such as aluminum foil.)[2]

(*c*) *Abrading Medium.*—A firm, hard-grain abrasive cloth. No. 180 Silicon Carbide Cloth of the Carborundum Co., Niagara Falls, N. Y., has been selected as standard.

(*d*) *Rubber Backing for Abrasive Cloth.*—A solid section of soft rubber $1\frac{3}{8}$ by $\frac{5}{8}$ by $\frac{11}{32}$ in., having a Durometer test value (determined in accordance with the Tentative Method of Test for Indentation of Rubber by Means of a Durometer (ASTM Designation: D 676)[3] of 45 to 50. A Faber eraser No. 112 is suitable.

(*e*) *Rubber Bed for Supporting Specimen.*—Rubber Apron Cloth $2\frac{1}{4}$ by $3\frac{1}{4}$ in. by $\frac{1}{16}$ in. thick, having a Durometer test of 90 to 95.

Reagents:

4. Standard Ink.—The ink used for this test is in accordance with the following formula:

	Grams
Tannic acid	11.7
Gallic acid crystals	3.8
Ferrous sulfate	15.0
2.72 *N* hydrochloric acid, U. S. P. dilute	12.5
Carbolic acid (phenol)	1.0
Soluble blue (Schultz No. 539, C.I. 707)	3.5
Distilled water to make a volume of 1000 ml at 20 C (68 F)	

All chemicals shall be of cp quality. The dye specified should be used because some blue dyes react with carbolic acid to cause a film having a metallic appearance. The ink is made as follows: Dissolve the tannic acid and gallic acid in about 400 ml of water at about 50 C (122 F). In a separate vessel, dissolve the ferrous sulfate in about 200 ml of water which contains the HCl. In a third vessel dissolve the dye in about 200 ml of water. Mix the three solutions in a 1-liter volumetric flask, rinse the vessels with small portions of water and add the rinsings to the flask. Add the carbolic acid and dilute with water to 1-liter at 20 C (68 F).

Test Specimen:

5. The test specimens shall be cut from samples selected as prescribed in the Standard Method of Sampling Paper and Paper Products (ASTM Designation: D 585).[4] The specimens shall be $2\frac{3}{4} \pm \frac{1}{16}$ sq in.

Conditioning:

6. (*a*) The specimens shall be conditioned before testing in accordance with

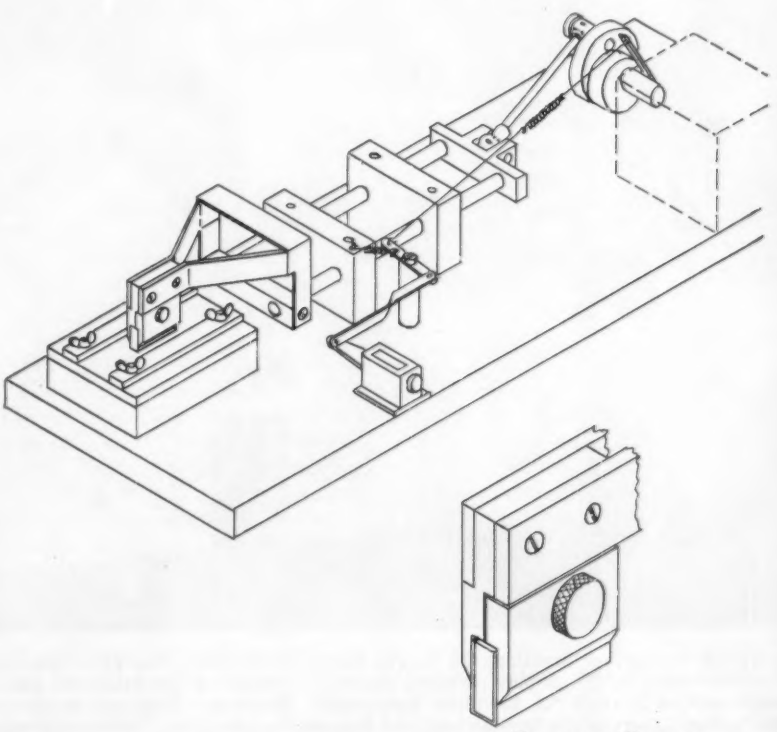


Fig. 1—Erasure Tester

[1] P. W. Codwise, "Determination of the Erasing Qualities of Paper," *Technical Association Papers*, Series 28, p. 69 (1945).

[2] The pen described by Schur and Levy, *Technical Association Paper*, Series 29, p. 160 (1946) is also suitable.

[3] 1949 Book of ASTM Standards, Part 6, p. 1039.

[4] 1949 Book of ASTM Standards, Part 4, p. 886.

the Standard Method of Conditioning Paper and Paper Board (ASTM Designation: D 685).[5] Tests shall be made in an atmosphere conditioned in accordance with Method D 685.

(*b*) Cut a piece of the Silicon Carbide cloth 1½ by 1 in., with the grain the short dimension, and fold it, parallel to the grain around one of the longer narrow edges of the 1⅜ by ⅝ by $\frac{11}{32}$-in. rubber backing. Fit this combination into the erasure head with the abrasive cloth surface exposed, taking care not to crack the abrasive face.

(*c*) Determine accurately the thickness of the specimen. Using the standard ink, draw upon it a cross-hatch line 1 in. long with ½-in. long cross-hatchings spaced about ½ in. apart. Hold the drawing pen set at an opening of 0.001 in., in a position perpendicular to the surface and use just enough pressure to draw a continuous line. The nibs of the pen should not be sharp enough to cut the surface of the specimen. Successful conduct of the test depends upon the proper relation of the paper and abrasive medium during the erasing process. To accomplish this, lower the erasure head with the abrasive cloth and backing loosely in place upon the rubber bed prior to inserting the specimen and hold the erasure head firmly in place but without downward pressure while tightening the screw which holds the erasure head in a position of uniform contact with the bed.

[5] 1949 Book of ASTM Standards, Part 4, p. 921.

(*d*) Allow the ink mark on the specimen to dry thoroughly, which generally requires about five minutes, then place and center the design upon the rubber apron cloth of the abrading machine, being sure that the cloth and specimen are carefully smoothed out. Lower the erasure head upon the specimen and firmly tighten the screws of the paper clamps to hold the specimen in place. Start the motor and determine the number of single strokes of the head required to completely erase the design. During the operation, note the behavior of the surface, especially its tendency to fuzz.

(*e*) Upon completion of the first erasure of the lines including the centerline and the cross-hatchings to a distance of at least $\frac{1}{16}$ in. on either side, remove the specimen from the machine and carefully examine it. Rewrite upon the erased part of the specimen as before, and note the difference in writing characteristics with special attention to the tendency of the lines to feather. Remove the abrasive cloth from the machine, discard it, and insert a new piece.

(*f*) Carry out a second erasure in the same manner as the first one, making the same observations. Repeat the process until the specimen has been rubbed through.

(*g*) Make at least five complete tests from each side of the paper and with and across the grain.

Report:

7. The report shall include:

(*1*) *Erasure number* which shall be the average number of strokes for each erasure,

(*2*) Average thickness of sheet removed in the first erasure,

(*3*) Tendency of the sheet to fuzz,

(*4*) Writing characteristics of the erased surface, and

(*5*) The number of strokes for the first erasure.

APPENDIX

A1. The special type of instrument which has been designed especially for this test, and is shown in Fig. 1, simulates the rolling and rubbing action of the erasure procedure and is required for this test. The available rotary types of abrading machines are not suitable because the rolling and scuffing action is absent.

A2. The result of the first erasure is in practice generally the most important, and if so desired, emphasis can be placed upon the relation of the first erasure to that of the remainder of the sheet in making the report.

A3. For routine mill tests, it is not necessary to continue the test until the paper is completely worn through. In this case, the number of strokes required for the first erasure and observations on the condition of the erased portion of the sheet, and on its writing quality after erasure are generally sufficient.

Discussion of ASTM Terms Relating to Methods of Testing*

W. N. FINDLEY.[1]—In response to a request from Mr. McVetty, Chairman of Subcommittee 3, Task Group on Review of Definitions, Committee E-1 on Methods of Testing, the following suggestions for revision of definitions were sent to him by letter during the period February, 1950 to June, 1951. It appears to me that it should be entirely possible to harmonize the definitions contained in a number of the Society's specifications. It also seems that Standard Definitions E 6 – 36 might well be revised in several respects and that many new definitions should be added.

STANDARD DEFINITIONS OF TERMS RELATING TO METHODS OF TESTING (E 6 – 36)[2]

Stress.—It is suggested that separate definitions be given for nominal stress and for true stress. It is suggested that the words "which resist a change in the form of a body" be deleted from the first sentence. The definition of stress does not require a change in form of the body.

Strain.—I question the advisability of limiting the definition of strain to deformations which accompany stress. Thermal stress is a commonly used term; why not thermal strain? Time stress is used in photoelasticity; why not time strain? It is also suggested that the following sentence be added to the definition: "That is, it is dimensionless."

It would also seem desirable at this time to include both nominal strain and true strain in the definition.

Proportional Limit.—It would seem to be highly desirable to place the definition for proportional limit in boldface type, in the same manner as elastic limit, since the two terms currently mean entirely different things.

Yield Strength.—It seems to me that the definition given is inconsistent with the method described for obtaining the quantity. It is suggested that the following might be a suitable revision: "Yield strength—the stress at which the material exhibits a specified offset from the initial tangent line." This change is suggested because the methods described do not include determination by the permanent set technique, nor is this technique used in practice.

Tensile Strength.—It is suggested that the last word of the definition be changed to, "Withstanding" and that the following phrase be added, "In a short-time test conducted under prescribed conditions."

It is further suggested that the definition differentiate between nominal tensile strength and true tensile strength, as based on the cross-sectional area at rupture.

Compressive Strength.—The comments just preceding apply also to the definition of compressive strength.

Modulus of Elasticity.—I believe that the words "elastic limit" are incorrectly used in this definition. It is my opinion that the "proportional limit" should be substituted, since materials may exhibit a curved stress-strain diagram and yet be perfectly elastic. It is further suggested that the values defined should be called the "initial tangent modulus of elasticity" and that additional definitions be added covering the "secant modulus" and the "tangent modulus."

Other Definitions.—I feel that several additional definitions should be added to this list. Those pertaining to tension tests might include the per cent elongation, the residual elongation, the reduction in area, rate of straining, rate of

* The first discussion of this subject appeared in the May, 1952 issue of the ASTM BULLETIN, p. 66. Additional discussion is invited. Please address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Research Associate, Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill.

[2] 1949 Book of ASTM Standards, Part 1, p. 1228; Part 2, p. 986; Part 3, p. 1263; Part 4, p. 1213; Part 6, p. 1335.

stressing, upper yield point, and lower yield point.

It is also suggested that Note 14 appearing on page 594 of Method D 638 – 49 T[3] be included in the definition for E 6.

Tentative Method of Test for Tensile Properties of Plastics (D 638 – 49 T)[3]

I see no reason for including definitions of terms both in the body of the method, in the Appendix, and also under symbols.

2(*a*) *Tensile Stress.*—The definition for tensile stress is the same as in E 6, except that it is here restricted to a tension test specimen. It is suggested that the definition used in E 6 be substituted.

2(*b*) *Extension.*—It seems unnecessary to define the term "extension."

2(*c*) *Strain (or Unit Extension).*—I feel that the term "unit extension" is a misnomer and should be deleted. Unit extension means to me an extension of one unit; that is, 1 in., 1 ft, 1 mile. Again I feel that the more general definition of strain as given in E 6 would be preferable and that the equations given in the Appendix would serve to illustrate the use of the definition for a tension specimen.

2(*e*) *Percentage Elongation.*—I think that this definition is preferable to the more commonly used value based on the residual extension after fracture, because relaxation and other recovery phenomena affect the length obtained after fracture. For some materials this would be very time sensitive. A term such as "residual elongation" might be better to use when the length after fracture is measured.

"Residual elongation" I would define as follows: residual elongation is the extension measured 1 min after rupture of a tension test specimen, expressed as a percentage of the original length of the measured elongating section. The length of the measured elongating section must be stated.

2(*i*) *Offset Yield Stress.*—In deference to the long-established use of the term "yield strength" I suggest that the term be called "offset yield strength."

Appendix Definitions:

1. *Tensile Strength.*—I suggest replacing the words "required to break a test specimen" with the words "during a tension test."

2. *True Ultimate (or Tensile) Strength.*—It is suggested that the definition for true tensile strength be reworded as follows: "True tensile strength is the true stress at rupture of a tension specimen as computed from the cross-sectional area at rupture at the point of fracture."

The following terms seem to me to be entirely unnecessary: Unit Extension, Ultimate Extension, Ultimate Strain, Ultimate Unit Extension, Percentage Ultimate Extension, Nominal Reduction of Area, Nominal Unit Reduction of Area, True Reduction of Area, True Unit Reduction of Area.

21. *Upper Yield Stress* and 22. *Lower Yield Stress.*—In deference to the long-established usage of the term "yield point" it is suggested that the word "stress" be replaced by "point" in the term being defined.

24. *Rate of Loading.*—The following rewording is suggested: "Rate of loading is the time-rate of change in tensile load carried by the specimen and is equal to the slope of a load *versus* time diagram."

25. *Rate of Stressing.*—It is suggested that this definition be reworded in the same manner as item 24.

27. *Mean Rate of Stressing* and 28. *Mean True Rate of Stressing.*—It is suggested that items 25 and 26 cover the cases described by 27 and 28 and that items 27 and 28 have the disadvantage that they are meaningful and reproducible only if the rate of loading is constant throughout the interval of strain specified. For these reasons it is suggested that items 27 and 28 be omitted.

I use the following as a practical expedient: "Nominal rate of straining: the slope of a diagram of strain *versus* time measured as the slope of a straight line drawn so as to represent the portion of the curve just below the strain corresponding to the apparent proportional limit of the stress-strain curve."

This procedure does not avoid the plotting of curves and measuring slopes. It does, however, give one value of the quantity for comparative purposes. It is my opinion that it would be best to use the nominal head speed of the testing machine when you are unwilling to go to the trouble of plotting curves.

A corresponding term for rate of stressing might be: "Nominal rate of stressing: the slope of a diagram of stress *versus* time measured as the slope of a straight line drawn so as to represent the portion of the curve just below the apparent proportional limit of the stress-strain curve."

31. *Elastic Modulus.*—As mentioned in connection with E 6, it is felt that the word "elastic" is incorrect and should be replaced by "proportional."

[3] 1949 Book of ASTM Standards, Part 6, p. 585.

Value of ASTM Noted in SAMA Talk

R. C. Mallett, Chief Chemist, Whiting Refinery, Standard Oil Co., gave an address May 8, 1952, as part of the panel discussion, "Tools of Science for the Future," which was held at the annual meeting of the Scientific Apparatus Makers Assn. in Chicago. Mallett congratulated the apparatus industry on the remarkable strides it had made in the development of new and improved apparatus during and since the war. In answer to a request made him to offer suggestions which might facilitate future progress and better enable the industry to meet the needs of its customers, Mallett made three suggestions: The first was to urge greater cooperation between apparatus makers and the users of their products in the design and preliminary evaluation of new apparatus, while the last was that so-called "price models" be avoided. He pointed out that the petroleum industry wishes to obtain quality equipment at minimum cost and is not interested in receiving inferior equipment at any cost.

The second suggestion to apparatus makers dealt with the relationship between them and the various standardization bodies. He stated in part:

". . . I also take this opportunity to urge greater participation in the activities of standardizing bodies, such as the American Society for Testing Materials. Being engaged in the refining of petroleum, we are very active in the work of ASTM Committee D-2 on Petroleum Products as well as in the work of other ASTM Committees. Through the work of this committee and the parent Society some of you share our responsibility for standardizing analytical methods and equipment. Those members of the Scientific Apparatus Makers Assn. who carry company membership in the various committees of the ASTM are making a valuable contribution to the work of the Society through their efforts to meet requirements for new laboratory equipment. . . . As industry adopts, and the ASTM standardizes, more and more instrumental methods of analysis, participation in the work of the ASTM will become increasingly helpful and profitable to you.

"Your participation in . . . cooperative work also will result in establishing more realistic specifications or manufacturing tolerances on laboratory apparatus."

DETROIT—SPRING MEETING

See December issue of the ASTM Bulletin for advance news of the 1953 Spring Meeting.

More Unsolved Problems

Additional Research Projects from ASTM Committees

STATEMENTS of research problems submitted by the technical committees of the Society have been collected in a pamphlet, "Some Unsolved Problems," which may be obtained upon request to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

These problems have been presented in series in the BULLETIN and will continue in the issues through 1952. This issue includes:

Character and Statistical Nature of Fatigue Damage
Crystallization of $Ca(OH)_2$
Effect of Local Plastic Flow on the Notch Sensitivity of Metals in Fatigue
Magnetism in Copper Alloys

Character and Statistical Nature of Fatigue Damage

Statement of Unsolved Problem Contributed by Committee E-9 on Fatigue

Problem:

There is need for information about the nature and extent of the damaging readjustments which occur prior to the formation of a fatigue crack in a member subjected to repeated stress. Since metals are polycrystalline, the random variations in strength of individual crystals throughout the structure result in a heterogeneous reaction of the material to the imposed stresses; this leads to statistical variations in results of tests of like specimens under similar conditions. The factors which control the statistical "average" fatigue strength properties of polycrystalline metals must be known before the designer of machines can predict the most probable fatigue strength of full-sized members subjected to typical service conditions.

Present State of Knowledge:

It is well known that materials subjected to repeated stressing behave in an inelastic manner on a microscopic scale. There is visible evidence of slip within crystals at stress levels below the nominal "elastic strength" of the metal. Some investigators have also reported that initial stresses existing in a member at the start of a test may be vastly altered by the repeated stresses imposed during service. Thus the chance microscopic and submicroscopic readjustments which take place within the metal during repeated stressing lead to marked changes in strength characteristics of the metal. These are of prime importance in controlling the statistical dispersion in life of a particular member under repeated stressing, or in determining the "fatigue strength" of the member. Since the metal does not behave in accordance with the assumptions of homogeneity and isotropy employed in the theory of elasticity, new concepts of the mechanism leading to the formation of a crack must be developed and correlated on a statistical basis before rational design procedures can be evolved.

Questions That Need to Be Answered:

1. What is the sequence of mechanical readjustments and strength changes that occur within the crystalline structure during repeated stressing?
2. Upon what factors does the statistical variation in fatigue life of a member depend?
3. Are the structural readjustments that take place within the polycrystalline material the same for ferrous metals as for non-ferrous metals?
4. How can the fatigue life of a member subjected to repeated stressing be predicted from a knowledge of the structure and the "average" mechanical strength characteristics of the polycrystalline material?

Introductory References:

(1) Paul Feltham, "Fatigue in Metals: A Critical Survey of Recent Research Theories," *Iron and Steel*, Vol. 21, October, 1948, pp. 431–436.

(2) Proceedings of the "Conference on Fatigue and Fracture of Metals" at Massachusetts Institute of Technology, June 12–22, 1950 (in Press).

(3) J. A. Bennett, "A Study of the Damaging Effect of Fatigue Stressing on X-4130 Steel," *Proceedings*, Am. Soc. Testing Mats., Vol. 46, pp. 693–710 (1946).

Additional information may be obtained from T. J. Dolan, Talbot Laboratory, University of Illinois, Urbana, Ill.

Crystallization of $Ca(OH)_2$

Statement of Unsolved Problem Contributed by Committee C-7 on Lime

Problem:

Quicklime, slaked to a putty or milk by the addition of the correct amount of water, usually produces a suspension of finely divided particles of $Ca(OH)_2$ with an average particle size which is less than 1 micron. Occasionally, for unknown reasons, the lime will produce crystals of $Ca(OH)_2$. These are clear colorless hexagonal crystals and range in size up to 100 microns or even more. They are hard, abrasive, and very slow in reaction. If the lime is used as a lubricant, for example, in wire drawing, the crystals will scratch and mar the wire and abrade the dies. If the lime is to be used as a chemical, for example, in the preparation of precipitated $CaCO_3$ or $CaSO_4$ pigments, the poor reactivity results in free lime being left in the product.

Present State of Knowledge:

Practically nothing is known concerning the conditions which cause or prevent the formation of these crystals.

Questions That Need to Be Answered:

Determination of the cause of the occasional formation of crystalline $Ca(OH)_2$ in slaked lime putties or slurries.

Introductory References:

The trade literature has occasional references to the formation of these crystals but apparently there are no references to any technical studies.

Additional information may be obtained from James A. Murray, Room 7-006, Massachusetts Institute of Technology, Cambridge 39, Mass.

The 50th Anniversary Year is a good year to suggest names for Society Membership

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To the ASTM Committee on Membership,
1916 Race St., Philadelphia 3, Pa.

Gentlemen:

Please send information on membership to the company or individual indicated below:

_____

_____

This company or individual is interested in the following subjects: indicate field of activity, that is, petroleum, steels, non-ferrous, etc,

_____

Signed_____

Date_____ Address_____

Effect of Local Plastic Flow on the Notch Sensitivity of Metals in Fatigue

Statement of Unsolved Problem Contributed by Committee E-9 on Fatigue

Problem:

It has generally been assumed that local plastic flow at the bottom of a notch reduces the stress concentration at this point and so would make the element less liable to fatigue failure. However there is not sufficient information available to make a quantitative evaluation of this effect, which might be of considerable practical value. Also, some recent work (1) has shown that while there is a large concentration of strain at points of stress concentration when the local stress exceeds the yield strength of material, this affects only the mean stress and not the stress range at these points. This indicates that the effect of such local deformation would have only a minor effect on the fatigue strength of a part.

Present State of Knowledge:

Very little exact information exists on this problem. Some studies have been made (2) utilizing X-ray techniques to measure the residual stresses near a notch and correlate them with the fatigue behavior. These have shown that in some cases there is a beneficial effect of local plastic deformation due to the residual compressive stress set up a short distance below the bottom of the notch which decreases the rate of propagation of the fatigue crack through this region, even though there was no change in the number of cycles required to initiate the crack. Undoubtedly more information can be obtained by a critical study of the extensive data on the effect of notches on fatigue properties, but most of these data are of little value because the condition of the surface of the metal in the notched specimens was not the same as that in the smooth specimens.

Questions That Need to Be Answered:

1. How does the occurrence of plastic deformation near the bottom of a notch affect the relation between the range of applied load and the range of stress at the point of stress concentration?
2. Does this range of stress remain constant after many repetitions of stress?
3. Is the fatigue behavior of the metal at the bottom of a notch, for a given stress range, the same as the behavior of a smooth specimen for the same stress range?
4. What is the effect of the residual stress due to plastic deformation on the propagation of fatigue cracks?
5. If there is an increase in fatigue strength due to plastic deformation at the bottom of a notch, can this effect be applied to increase the fatigue strength of actual structural elements subjected to fluctuating loads?

Introductory References:

(1) G. E. Griffith, "Experimental Investigation of the Effects of Plastic Flow in a Tension Panel with a Circular Hole," *Technical Note 1705*, Nat. Advisory Committee for Aeronautics (1948).

(2) J. T. Norton, D. Rosenthal, and S. R. Maloof, "X-Ray Diffraction Study of the Effect of Residual Compression on the Fatigue of Notched Specimens," *Welding Journal*, Vol. 25, p. 729s (1946).

(3) D. Rosenthal, G. Sines, and G. Zizicas, "Effect of Residual Compression on Fatigue," *Welding Journal*, Vol. 28, p. 98s (1949).

Additional information may be obtained from T. J. Dolan, Talbot Laboratory, University of Illinois, Urbana, Ill.

Magnetism in Copper Alloys

Statement of Unsolved Problem Contributed by Committee B-5 on Copper and Copper Alloys, Cast and Wrought

Problem:

Instruments containing compass needles or other magnetic devices may be subject to error because of small amounts of magnetism in housing, frames, and nearby parts made of material ordinarily regarded as nonmagnetic. Specifications for the copper alloys commonly used in instrument construction are based on considerations of manufacture and structural services; they permit maximum contents of iron as impurity so high in many cases as to render the material unfit for use in magnetic instruments, even when the actual iron content is much less than the stated allowable maximum.

Present State of Knowledge:

During the war the Pitman-Dunn Laboratory of Frankford Arsenal sponsored research at Lehigh University to study the above problem. A summary of this work has been presented in a paper by Butts and Rieber (1) and indicates, in the field of wrought copper alloys, that copper and copper-nickel-zinc alloys (nickel silver) are acceptable materials.

It indicates also that in the cast copper-base alloys, three of the common commercial alloys, when properly heat treated, may be used. However, Curran in his discussion of the above paper, indicated that the heat treatment necessary to remove magnetic susceptibility may otherwise damage these alloys.

Questions That Need to Be Answered:

During the last war, the only solution proposed was to restrict the iron content in copper-alloy castings to such a low figure that only primary metal might be used. Further research work is needed:

1. To provide data on whether leaded or other free-machining wrought coppers may be used in this service.
2. To develop a heat treatment that will remove magnetic susceptibility without other damage.
3. To develop simple and easily applied test methods to determine that magnetism is not present in either wrought or cast alloys.

Introductory References:

(1) Allison Butts and Paul L. Rieber, Jr., "Magnetism in Copper Alloys: The Effect of Iron as Impurity," *Proceedings*, Am. Soc. Testing Mats., Vol. 49, p. 857, (1949); Discussion, p. 885.

Additional information may be obtained from Frankford Arsenal, the Naval Research Laboratory, and Carnegie Institute of Technology.

Inquiries concerning the "Advantages of Membership" will be welcomed during the Society's 50th Anniversary Year

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To the ASTM Committee on Membership
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Gentlemen:

Please send me information on Membership in ASTM and include a membership application blank.

Signed_____

Address_____

Date_____

TECHNICAL COMMITTEE NOTES

Two-Day Meeting of Committee B-4 Held in Washington

A FURTHER increase in the already broad scope of activities of Subcommittee VIII on Metallic Materials for Radio Tubes and Incandescent Lamps, of Committee B-4 on Electrical Heating, Resistance, and Related Alloys, was evidenced by the organization of Section G on Clad and Plated Materials Used for Radio Tubes and Lamp Uses at the recent meeting of this committee in Washington, D. C., September 25 and 26. This new section is under the temporary chairmanship of F. J. Biondi, Bell Telephone Laboratories, Murray Hill, N. J., and anyone interested in participating in the work of this section should get in touch with Mr. Biondi. Presently under consideration in the section are specifications for (*a*) nickel-clad steel strip, (*b*) nickel-plated steel strip, (*c*) aluminum-clad steel strip, and (*d*) steel, aluminum-clad on one side and nickel-clad on the other.

The interest in the activities of this group are apparent from the fact that more than 20 members were present representing a 70 per cent response from the groups originally approached.

The subsection on methods of chemical analysis has developed analytical methods for the determination of cobalt, copper, manganese, iron, and titanium in electronic nickel. These methods were approved by Committee B-4 and published as an appendix to the 1952 report of the committee—as information only. These methods are currently being reviewed by Committee E-3 on Chemical Analysis of Metals. Meanwhile, the section is continuing its work on methods of analysis of electronic nickel and is now directing its efforts toward the development of analytical procedures for the determination of magnesium, aluminum, and silicon. In connection with the spectrochemical analysis of electronic nickel, quantities of nickel oxide from two types of electronic nickel have been accumulated and are stored at the National Bureau of Standards. Samples of these oxides are currently being distributed to laboratories for analysis, and the results will be used to establish standard samples.

The question of "surety of contact" which has long been a problem in Subcommittee X on Contact materials seems to show promise of resolution at some early date as an increasing number of companies participate in the round-robin testing of various contact materials including fine silver, coin silver, tungsten, and copper. These tests have been run using the ASTM Standard Method for Life Test of Electrical Contact Materials (B 182). In connection with the meeting of Subcommittee X on Contact Materials, H. R. Stauss of the Bureau of Ships presented an interesting talk on "Electrical Contact Transients in Simple Electrical Circuits."

ASTM Tentative Specifications for Round Chromium-Copper Wire for Electronic Devices (B 268 – 52 T) were submitted to the Society for its approval at the Annual Meeting as the first of a group of such specifications. Work is now in progress on specifications for tungsten and molybdenum wires.

Two new specifications have either been approved by Committee B-4 or are currently out to letter ballot of the committee. These include the recommended practice for the sublimation testing by the electrical resistance method and the proposed tentative method of test for determining the hardness of contact materials.

The new Bibliography on Electrical Contacts which will be available before the end of the year will embody not only the abstracts which appeared in the original book in 1943, but the material contained in the intervening supplements as well as the abstracts of articles which appeared in 1950 and 1951.

In view of the increasing interest in the electronics field, the committee agreed that the "ASTM Standards on Electrical Heating, Resistance and Related Alloys," which last appeared in September, 1948, should be broadened to include such items as mica, solders, acetone, hardness testing and similar topics of interest to the electronics field. This will result in a manual that will be of interest not only to those groups interested in heating and resistance alloys, but to any one interested in the manufacture of electronic tube components.

An interesting informal evening session was held Thursday, September 25, with a dinner at the Wardman Park Hotel followed by a talk by Dr. Ralph J. Slutz on automatic computers and particularly the SEAC (Standard Eastern Automatic Computer). Dr. Slutz discussed the early beginnings of computers and went on to describe the differences between the so-called "analog" and "digital" type of computers. The actual operating time of the SEAC ranges from 85 to 90 per cent—24 hours a day, 7 days a week. The problems for this "magnetic brain" are prepared by a group of 50 mathematicians. The SEAC is one of the largest computers in the country and takes up an area equivalent to two fair-sized rooms. Its accuracy and scope of operations are based on the use of 16,000 electronic tubes. One of the most interesting features is that involving the efficient use of the time of the working mathematicians. As there is no means of determining the length of time that it will take the machine to analyze the problems, a means has been devised whereby the problem at any stage can be recorded on a tape similar to that used in tape recording instruments. An entire problem and its analysis up to any point can be removed from the machine in eight seconds and progress can be resumed by reinserting this tape, the necessary time for reinitiation of the problem also being eight seconds.

New Cellulose Committee Holds First Big Meeting

THE first "full-dress" meeting of Committee D-23 on Cellulose and Cellulose Derivatives since its organization was held at Atlantic City in September.

Gratifying progress has been made on the organization of the subcommittee groups. Although this field of activity is just now being developed in ASTM, through the organization of a separate technical committee, a great deal of work has been under way for some time in such other groups as the American Chemical Society and the Technical Association of the Pulp and Paper Industry.

Subcommittee II on Cellulose has the largest organization and scope. Subcommittee Chairman R. M. Levy announced that organization of eleven task groups was either complete or under way. These task groups will cover the following subjects: Absorption & Color; Alpha, Beta, and Gamma Cellulose; Ash Constituents; Disperse Viscosity; Extractives; Lignin; Moisture; Molecular Chain Length; Pentosans; Sampling; and Soda Solubles. Reports were

presented, indicating such activities as surveys and round-robin tests, as well as several test methods in various stages of completion, in these several interlocking groups of Committee D-23, ACS, and TAPPI.

Subcommittee III on Organic Esters, with L. B. Genung as Chairman, has already studied two existing ASTM methods for revision in order to include moisture, pre-acidity, and viscosity determinations.

Subcommittee IV on Inorganic Esters, with Karl Gilbert as the new chairman, reported a review of ASTM Specifications and Tests for Soluble Nitrocellulose D 301. This subcommittee will be primarily interested in nitrocellulose materials.

Subcommittee V on Cellulose Ethers, with R. S. Apple as Chairman, discussed its proposed activity which will include a review of ASTM methods developed by Committee D-1 on Paint, Varnish, Lacquer and Related Products, the modification of methods now used with ethyl cellulose for use with methyl cellulose, and plans for a group of laboratories to analyze samples of sodium carboxymethyl cellulose on a statistical basis. A new subcommittee on statistical analysis was authorized.

The formal acceptance of by-laws prepared for the committee was deferred until the next meeting, as it was felt advisable to use them on a trial basis for this period.

Permanent officers were elected as follows:

Chairman—F. A. Simmonds, U. S. Forest Products Laboratory
Vice-Chairman—L. B. Genung, Eastman Kodak Co.
Secretary—W. W. Becker, Hercules Powder Co.

The next meeting of the committee was planned for September, 1953, at the time of the American Chemical Society meeting in Chicago.

Definitions and Test Methods Discussed at Sandwich Constructions Meetings

THE property of peel was the subject of considerable discussion at the October meeting of Committee C-19 on Structural Sandwich Constructions at Massachusetts Institute of Technology, Cambridge, Mass. Those present, a large attendance of members and guests, gained a better appreciation of the fundamental thinking and research which is necessary to measure and evaluate this property of peel which is defined as the property, applied to sandwich constructions, of resisting separation of the face and core.

A proposed tentative method for measuring peel resistance of sandwich construction was presented involving a strip loading of the facing using any hydraulic or mechanical tension testing machine. Two types of cylinder or drum testing apparatus were also described and discussed. It is planned to circulate in draft form proposed methods covering the strip loading and the drum types for further comment.

Further test methods are needed for evaluating core material and attention will be given to the development of test methods for measuring compression, delamination, shear, and heat distortion.

Not much progress was reported in the development of data on performance and simulated service. A survey will be made to obtain details on the design of a suggested cubicle for testing of sandwich construction. The interest of the committee will also be solicited by letter on the establishment of exposure test panels at the ASTM exposure sites. Data and experience will be collected on fatigue testing as a possible first step toward standard test methods.

George Gerard, New York University, described an interesting type of fundamental test for measuring impact. This consists of a closed cylindrical tube by which impact on a plate of sandwich construction is measured by the time required to equalize built-up pressure within the tube with atmospheric pressure when a paper jacket is punctured.

Several definitions of terms were discussed and revised definitions of the terms "insert" and "sizing" will be submitted for letter ballot of the committee. Classification of core materials was agreed upon embodying present usage of terms as far as possible. Six classifications are made as follows: (1) grid; (2) honeycomb; (3) corrugated; (4) waffle; (5) foam; and (6) convolute. The honeycomb classification is further subdivided into expanded, preformed, and fluted (parallel and cross) types. The foam classification is divided into preformed and foamed-in-place types.

Two papers were presented at the committee dinner held at the Hotel Bellevue: "Plastic Foams," by R. N. Kennedy, Dow Chemical Co.; and "Proposed Qualifications and Quality Control of the Fabrication of a Metal Sandwich Wing Tip," by Harold H. Rosenbaum, Consolidated Vultee Aircraft Corp.

The next meeting of the committee is planned for April, 1953, in Dallas, Tex.

Definitions Under Study by Ceramic Whitewares Group

THE term "vitreous" is associated with the several types of ceramic whiteware and is evaluated in terms of the ability of the ware to absorb water. The term "vitrified" is used synonymously with this term. Committee C-21 on Ceramic Whiteware, since its organization in 1948, has had as one of its major projects, the definition of the term "vitreous" and other associated terms such as "near-vitreous," "semi-vitreous," and "non-vitreous," along with some thirty odd other terms relating to ceramic whiteware. This has been a difficult project and the Subcommittee on Nomenclature has spent much time on it.

At the Fall meeting of the committee, held at Bedford Springs, Pa., on September 25, a significant advance was made toward agreement on how these particular terms might be defined and be accepted by the entire industry. It was agreed to formulate and study a classification chart in which would be set up actual types or classes of vitrification with percentage limits for each type and use. This chart would then be referred to in the definitions of terms related to it, thus removing the objectionable feature of including limits in the definitions.

Of interest among the other activities of the committee was the presentation of a proposed tentative method of test for the determination of modulus of rupture of fired, cast, or extruded whiteware products; review of the results of the water absorption round-robin tests involving the boil and soak method and the vacuum method; and a review of the replies received to a questionnaire circulated to establish the feasibility of developing an autoclave test method for checking the tendency of whiteware products to crazing.

Reorganization is nearing completion in the groups concerned with raw materials in order to give an impetus to this phase of activity which has not made much progress to date.

Arc Resistance: (II) Effect of Testing Conditions on Tracking Properties of Thermosetting Insulating Materials*

By Murray Olyphant, Jr.[1]

SYNOPSIS

The conditions under which the arc-resisting properties of materials are determined can be varied by changing either the nature of the test atmosphere, the form of electrode arrangement, or the nature of the discharge. The results of tests are presented which reveal that materials in general are more resistant to tracking under arcs in nitrogen, hydrogen, and helium, and less resistant in an atmosphere containing 5 per cent chlorine, than they are in air alone. Arc resistance is shown to decrease with increasing specimen temperature, the rate of decrease varying somewhat among materials. Studies of comparative tracking properties under continuous current arcs, raised electrode conditions, and pulse arcs are discussed and indicate the following: The order of materials is dependent not only upon the nature of the discharge and arrangement of electrodes but also upon the value of current in a given type of arc. A second criterion of arc resistance is found in the minimum current or power below which a material will not track. The minimum tracking powers in the pulse and continuous arc tests are shown to be of the same order in spite of the widely different levels of current and voltage in the two arcs. It is concluded that power is a more basic factor in determining breakdown than arc current. A calculation of energy consumed in promoting tracking reveals that there are particular values of arc power at which tracking is most efficiently initiated.

ALTHOUGH a fundamental understanding of the processes through which materials break down under arcs may not be essential to their intelligent use, a knowledge at least of the comparative performance of various types of insulation under different arcing conditions would seem to be almost indispensable. To provide such information, users of insulation have devised a large variety of arc and tracking resistance tests, a number of which are described in an illuminating paper by Yarsley and Grant (1).[2] It is difficult to classify many methods for evaluating the arc and tracking resistance of a material, but most of those in common use depend either upon exposing a specimen to an arc drawn near its surface or upon the application to the material of electrolytes or contaminants which enable the passage of current across the specimen at low voltage. In either case, failure is generally considered to have occurred when, through the growth of carbonized tracks or trees (fusion in the case of inorganic materials), the sample itself becomes conducting.

The necessity for a variety of test methods arises from the now accepted fact that the comparative performance of materials can depend critically on the nature of the discharge to which they are exposed. Very little progress has been made in accounting, on the basis of chemical and structural differences, for the relative abilities of materials to resist tracking, and particularly for the significant changes in order which may occur when tests are run under different types of arcs. Lacking a theoretical approach to the problem, the designer must depend upon experimental data or experience in choosing materials for applications requiring arc resistance. Experience seems to indicate that in many cases only those tests are valid which simulate the conditions under which the material is to be used. A review of the work of other investigators has been presented in a previous paper (2).

Since published data concerning the arc resistance of materials have been and continue to be obtained almost invariably by the standard ASTM Method D 495-48 T,[3] it is important to consider under what conditions this test provides a reliable measure of relative performance. Fortunately for those who must evaluate arc resistance, there are many materials which do not seem to be overly sensitive to changes in the test method. Although it is possible, for example, to reverse the positions of alpha-cellulose urea and melamine in the test scale by various changes in conditions, both materials exhibit a usefully high arc resistance in a wide variety of tests. On the other hand, for want of theoretical understanding of arc resistance, there is no way of predicting from the evidence of one type of test how a new material will behave when unknown conditions are imposed.

The ASTM method furnishes data for applications where high-voltage, low-current discharges are anticipated. The advantages of the method consist in reproducibility of test conditions and in applicability to a wide range of materials. In these respects there is probably no other single test more generally useful. The disadvantages of the ASTM method are common to all arc-resistance tests—namely, restricted significance and an inability to furnish consistent and reproducible values for certain materials.

For the reasons noted, none of the common tracking tests can be considered a good research tool. In addition, the stepwise nature of the ASTM method and the use of a scale of values which is expanded at the low end make statistical interpretation of the data difficult. What is more desirable is a test which permits materials to be compared over a range of values of the important variables. Such a procedure not only facilitates comparisons under varied conditions but reveals trends which may differ among materials. Two of the studies discussed in this paper represent attempts to provide such information for continuous low-current arcs and for pulse discharges having peak currents in the neighborhood of several amperes. (It is expected to present the results of a similar investigation of radio frequency corona resistance in another paper.) Also included in this report are data concerning the effects on arc resistance of varying specimen temperature and of substituting other gases for air in the test atmosphere.

Although the work described consists largely of a number of independent experiments, their results all have a bearing on the comparative tracking behavior of materials and, where possible, an attempt is made to indicate the gen-

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* This is the second in a series of three articles on Arc Resistance. The first paper appeared in the ASTM BULLETIN, No. 181, April, 1952, p. 60.

[1] Minnesota Mining and Manufacturing Co., St. Paul, Minn.

[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

[3] Tentative Method of Test for High-Voltage, Low-Current Arc Resistance of Solid Electrical Insulating Materials (D 495 – 48 T), 1949 Book of ASTM Standards, Part 6, p. 384.

eral significance of each set of results. This report cannot provide the designer with specific answers to the problem of what material to use in a given instance. It can, however, suggest factors that may be important when something is known about the probable nature of the discharges to be expected and may provoke a cautious discrimination in the interpretation of test results.

The conditions under which materials are studied can be varied by changing either the nature of the test atmosphere or by the use of different forms of discharges and electrode arrangements. Since various tests of each sort are described and involve differing procedure and equipment, it has seemed desirable to refer the technical details of each study to the section in which the results of the study are presented.

The material employed consists (with the exception of polystyrene and glass-bonded mica in two tests) of commercially available thermosetting materials and fillers. Specimens were prepared by compression molding in positive molds 2- or 4-in. disks in accordance with the recommendation of the manufacturer.

Effect of Ambient Conditions

Arc Resistance at Elevated Temperature:

The effect of specimen temperature on arc resistance has been studied over the range from room temperature to 175 C. Arc-resistance test equipment conforming to ASTM Method D 495–48 T was employed with the electrodes mounted in a thermostated oven. Details of the standard test circuit and general procedure have been briefly described in the first paper under this title (2). Considerable effort was expended in an attempt to obtain consistent and reproducible results at temperatures above 100 C. However, in many cases the efforts were unrewarding. Variability in the values of a run increased with increasing temperature, in many cases becoming so great as to render average values meaningless. For such cases no values are listed.

The samples were preconditioned for at least 2 hr at the test temperature prior to testing. To avoid opening the temperature-controlled oven during a run, the specimen to be tested was mounted on a turntable which could be rotated by means of a shaft extending through the floor of the oven. Before conditioning, the samples were wiped with a cloth to remove foreign particles, and at the beginning of tests on each sample, the electrodes were cleaned and any residue adhering thereto was removed with crocus cloth. After changing samples, 15 min were allowed to restore temperature equilibrium.

TABLE I.—ARC RESISTANCE AT ELEVATED TEMPERATURES.

Material	Arc Resistance, sec (ASTM D 495 – 48 T)				
	25 C	75 C	125 C	150 C	175 C
Phenolics					
Wood-flour	3 (5)[a]	2 (5)	.....	2 (8)	2 (7)
Mineral	24 (5)	16 (5)	15 (8)	15 (18)	2 (9)
Melamine					
Alpha-cellulose	130 (5)	127 (5)	126 (8)	95 (11)	125 (9)
Asbestos	181 (5)		134 (9)	130 (8)	131 (8)
Urea					
Alpha-cellulose	128 (5)	90 (5)	77 (10)	52 (11)	30 (17)
Polystyrene	93 (5)	65 (5)	.....	.....	.....

[a] The number of observations is indicated in parentheses following the average.

As the temperature is increased above 125 C, postcuring becomes significant. Blistering can occur at still higher temperatures resulting in possible inconsistencies. Other sources of variation were frequent occasions of serious arc climbing, cracking of the sample, and difficulty in determining the end point when the carbonized area burst into flame.

The results of the study are recorded in Table I. In general a consistent trend to lower arc resistance occurs as the temperature is raised. Evidently the rate of decrease can vary among materials. The melamines appear superior in this respect. The drop in asbestos melamine from 181 sec at 25 C to 134 sec at 125 C is not highly significant, since the value of 181 sec depends somewhat critically upon test conditions.

Atmospheres Other than Air:

When other gases replace air as the test atmosphere, rather striking changes occur in the values of arc resistance obtained for most materials. The results of tests in nitrogen, helium, hydrogen, and 5 per cent chlorine are tabulated in Table II. For all gases the tests were run at atmospheric pressure with the sample and electrodes suitably mounted in a vacuum desiccator.

The procedure varied slightly with different gases. For nitrogen and helium the desiccator was evacuated to 1 cm of mercury or less, after which the gas to be used was admitted to a pressure of one atmosphere. This operation was repeated for each test. Although the procedure described leaves approximately 1.3 per cent by volume of air in the test atmosphere, no significant difference was observed in evacuating to the lowest pressure obtainable with the pump employed (approximately 1 mm). For hydrogen the method was similar but more drastic measures were taken to eliminate air, and provision was made to allow exposure of a fresh surface to the arc without opening the desiccator. The tests under chlorine required repeated evacuations followed by the admission of the proper amount of chlorine. The volume (or partial pressure) of chlorine was controlled by shutting off the gas at a pressure increase of 5 per cent of the ambient barometric pressure. The complexity of the above procedure necessitated that several tests be run between the scavenging and refilling operations.

Nitrogen.—It is to be noted that all the materials tested except phenolics show significantly higher values in nitrogen than in air. Ozone and nitrogen oxides produced by electrical dis-

TABLE II.—EFFECT OF VARIOUS GASES ON ARC RESISTANCE.

Materials	Arc Resistance, sec (ASTM D 495 – 48 T)								
	Air	Nitrogen		Helium		Hydrogen		5% Chlorine[a]	
	Approx.	Avg	Range	Avg	Range	Avg	Range	Avg	Range
Phenolics									
Wood-flour	2	2 (6)[b]	0	263 (5)	45	2 (10)	2		
Mineral	8	.....	..	254 (5)	3	162 (10)	100	.....	...
Rag	6	.....	..	....	..	7 (10)	6	.....	...
Cast	4	5 (5)	10	....	..	.....	...	.....	...
Transparent	4	.....	..	....	..	.....	...	Instant.	0
Melamine									
Alpha-cellulose	130	188 (10)	11	258 (5)	22	190 (10)	35	.....	...
Asbestos	181	208 (10)	44	325 (5)	45	192 (2)[c]	4	31 (5)	44
Cellulose	130	.....	..	....	..	181 (10)	5	5 (5)	1
Urea									
Alpha-cellulose	128	184 (5)	1	234 (5)	5	207 (10)	15	30 (5)	47
Glass-bonded Mica	306	.....	..	....	..	.....	...	217 (5)	56
Silicone									
Glass fiber	180–248	.....	..	....	..	.....	...	70 (5)	176
Alkyd									
Mineral	199	.....	..	....	..	.....	...	160 (5)	53
Fillers									
Wood-flour	15	34 (5)	14	283 (5)	13	.....	...	....	...
Alpha-cellulose	107	185 (5)	3	366 (5)	89	.....	...	....	...

[a] Values for chlorine are not necessarily comparable with those for other gases for reasons given in the text.
[b] The number of observations is indicated in parentheses following the average.
[c] Only two readings of asbestos melamine were obtained since the test was terminated by an explosion.

charges in air are known to contribute to the degradation of insulating materials (3). But this is usually a long-time phenomenon and since breakdown under arcs can occur in a matter of seconds, it seems probable that, although the chemical products of the discharge may contribute to a more rapid breakdown in air than in nitrogen, additional effects are present. Likely factors are the absence of combustion, a lower heating effect, or a reduction in the amount of higher frequency transients in the arc. Evidently the test conditions under nitrogen are not sufficiently ameliorated to overcome the tracking sensitivity of phenolics.

Helium.—All materials tested in the helium atmosphere using a 10-ma arc showed significantly higher arc-resistance values than were obtained under any other gas. The improvement in phenolics is particularly noteworthy. It was found, however, that the power dissipated in a 10-ma helium arc is considerably less than that produced by a 10-ma air arc. The test was repeated using an arc current of 18.6 ma, in an attempt to produce a power equivalent to a 10-ma air arc. Under the latter condition, wood-flour phenolic failed consistently on the first arc (2 sec). The mineral-filled phenolic was, however, practically unaffected by the increased current, dropping only to 249 sec. Other materials showed similarly slight effects. An anomalous result was found for alpha-cellulose melamine which improved to greater than 300 sec in the second test.

Since the change in current should have resulted in a dissipation of heat equivalent to that produced by the standard ASTM method, some other explanation is necessary to account for the extraordinary increase in arc resistance time for most materials. Several factors may be responsible. Chemical attack by gaseous products of the discharge should be materially reduced by the use of helium. The heat conductivity of helium is about six times that of air. Decomposition by combustion is eliminated. The arc voltage drop is less in helium than in air. It may also be significant that the transient oscillations normally of considerable amplitude are greatly reduced in the helium arc. It is possible that the process of track initiation is accelerated by the high amplitude transients normally present in the arc at the beginning of each half cycle.

Hydrogen.—The results of the tests in hydrogen are essentially similar to those obtained in nitrogen. The wood-flour and rag-filled phenolics are unimproved, the mineral phenolic much improved. Considerably higher than normal values result for all other materials.

Chlorine.—The decrease in arc resistance of all materials tested which resulted from the inclusion of 5 per cent chlorine in the test atmosphere is surprising. The effect on glass-bonded mica is perhaps the most unexpected. However, subsequent investigation revealed that the arc had become an almost continuous series of sparks upon the addition of chlorine. Since the milliameter employed to set the test current to 10 ma was a moving-vane instrument, the true rms current in the arc can have been significantly higher than the 10 ma specified because of high-frequency components. No modification of the circuit could be found to eliminate the behavior referred to, so that the results reported cannot be strictly compared to the values for other gases and for air. Nevertheless, it is doubtful that increased arc power alone can account for the increased severity of the arc when chlorine is present.

The results do suggest, however, that the dielectric strength of the ambient gas can be significant in determining the time-to-track under an arc of given current. The breakdown voltage of the gap and the arc voltage are considerably higher for the atmosphere containing 5 per cent chlorine than for air alone, characteristics probably due principally to the large coefficient of electron attachment of chlorine. It is probable that gases having high dielectric strength can effectively reduce tracking time at a given current, either because they cause excessive transient sparking or because greater arc power results. Helium with a lower dielectric strength and arc voltage improves arc resistance.

The effect of chlorine decreases rapidly as the concentration is reduced below 5 per cent so that at 1 per cent by volume approximately the same arc resistance values are obtained as are found in the standard test.

Two materials, glass silicone and asbestos melamine, were also tested by the same procedure using oxygen in place of chlorine. It was thought that the rate of combustion might be somewhat increased by the addition of chlorine and that a similar effect should therefore be observed with oxygen. However, no significant change in arc resistance was found upon increasing the oxygen content of the test atmosphere following the procedure employed for chlorine.

Special Test Methods

Since small variations in the procedure and physical elements of the arc-resistance test equipment can have a sigificant effect on the results obtained, a number of rigid specifications in a test method are necessary if reproducibility is to be achieved. In addition, an assumption that a certain rating of some materials is more valid than others is required *a priori*, so that the procedure and physical elements of the test can be chosen to give the desired rating. As the choice would naturally be based on experience with the behavior of materials in service, there is some assurance that the test can provide, in the case of a new material, at least an estimate of its arc-resisting properties under similar conditions. However, for research purposes, a test is required which allows the quantitative comparison of all materials under the same condition and permits controlled variation in this condition in order that the rates with which values change can be studied.

Low-Current Arc Resistance:

It has been found that if a high-voltage potential transformer is used as the potential source for the arc, and if the current is limited by a large series resistance in the secondary, stable arcs can be drawn between the standard electrodes at currents as low as 0.5 ma. The lowest current at which stable arcs can be produced in the standard test is somewhat less than 10 ma because the current limiting resistance is inserted in the primary. At currents below this value, the arc becomes a series of sparks presumably because of transformer reactances. (If 200,000 ohms are inserted in the secondary of the standard test circuit, stable arcs can be drawn at currents as low as 4 ma. In addition a quiter arc is obtained at the standard current of 10 ma.)

The circuit used for low-current arc-resistance tests is shown in Fig. 1(*a*). Resistance values found suitable at each of the test currents are given in Table III. At the higher currents, lower resistance could be employed. At currents above 10 ma, the standard test equipment was used.

The spacing of the standard electrodes was shortened to 0.125 in. to reduce transients at low currents. Previous experiment indicated that electrode spacing was one of the few variables that has little effect. Four-inch disks of each

TABLE III.—RESISTANCE VALUES FOR LOW CURRENT TESTS.[a]

Current, ma	R_1, ohms	R_2, megohms	R_4, ohms
0.5	50	36	1 000 000
1.0	0	36	420 000
2.0	0	15	305 000
3.0	0	7.5	190 000
5.0	0	2.75	114 000
7.5	0	2.0	76 000
10.0	0	1.0	50 000

[a] A value of 2200 ohms was employed for R_4 at all currents.

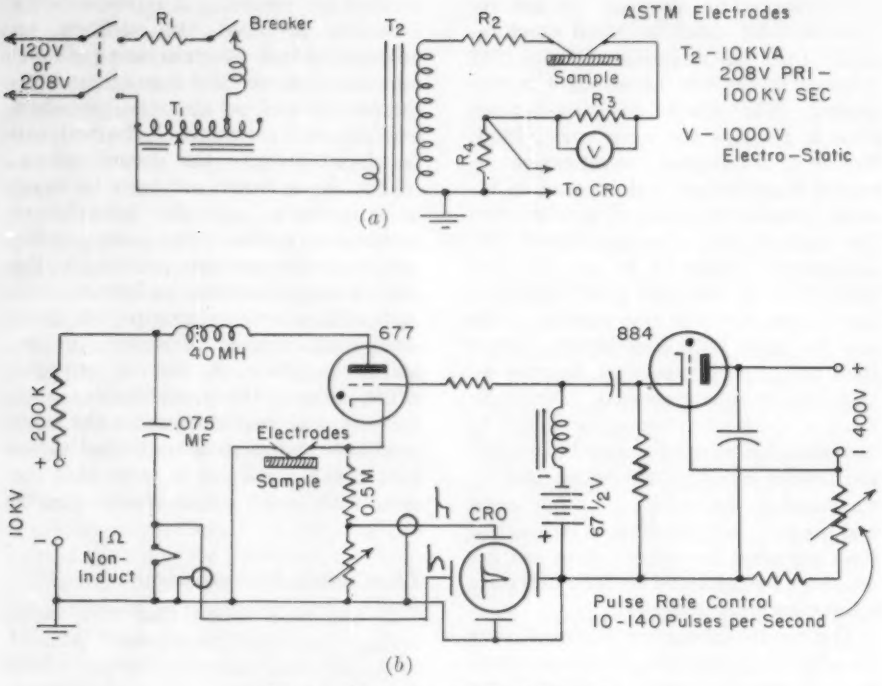


Fig. 1.—Experimental Test Circuits.

(a) Low-current continuous arc equipment.
(b) Pulse test generator.

of eleven materials were arranged in the following order:

1. Transparent phenolic
2. Alpha-cellulose melamine I
3. Diced phenolic molding board
4. Mineral alkyd
5. Wood-flour phenolic
6. Alpha-cellulose melamine II
7. Rag-filled phenolic
8. Asbestos melamine
9. Mineral phenolic
10. Alpha-cellulose urea I
11. Glass fiber silicone
12. Aniline formaldehyde
13. Alpha-cellulose urea II

At each of the test currents ten tests were run on each specimen, starting at the rim and progressing to the center. In order to avoid heating the sample and to obviate any effect that several consecutive tests on one material might have on the electrodes, the series of materials was tested singly first in the forward order and then in the reverse order, and so forth, until ten values had been obtained for each material. The results indicate that in some cases the nature of the material or materials tested immediately before a given specimen can have an effect on the values obtained on that specimen. If this is true, then the test conditions in the forward and backward series differed for some materials. However, in all cases, averages reported are means of all ten tests on a specimen. In addition, most of the poorer materials were eliminated from the runs at 7.5 ma and at currents higher than 10 ma, since tracking was too rapid for accurate measurement. By making repeated checks and resharpening when any evidence of dulling appeared, an effort was made to insure that the electrodes were continuously clean and sharp. In general such low currents erode the electrodes very little, so that only cleaning is necessary.

The volt-ampere values in Table IV were obtained with an electrostatic voltmeter connected across the arc and can serve as an estimate of arc power. The arc voltage at constant current may fluctuate considerably as the arc spots shift around on the electrodes so that the values shown are only approximate. The arc power factor cannot be exactly 1.0 since the voltage wave form contains a high proportion of odd harmonics although the current is more nearly sinusoidal.

Tests results are shown in Figs. 2 and 3. Failure was considered to occur when the sample tracked and the arc was extinguished. Mean values for all materials in Fig. 2 fall below and to the left of all materials in Fig. 3. To avoid confusion, rag phenolic and diced molding board are not included but follow the general trend shown in Fig. 2.

TABLE IV.—ARC VOLT-AMPERE VALUES.

Arc Current, ma	Arc Drop, volts	Apparent Power, volt-amperes
0.5	Unstable	1.0 (by extrapolation)
1.0	1900	1.9
2.0	1600	3.2
3.0	1400	4.2
5.0	1200	6.0
7.5	1030	7.7
10.0	950	9.5
12.0	900	10.8
15.0	850	12.7
20.0	805	16.1
30.0	753	22.6

At the lowest currents at which some materials tracked, failure did not occur in all ten tests, some areas of the specimens being apparently more resistant than others. Considering the incidence of nontracking as a fraction effective, this behavior is recorded in Table V.

TABLE V.—FRACTION EFFECTIVE FOR MATERIALS NOT FAILING CONSISTENTLY.

Material	Arc Current, ma							
	0.5	1	2	3	5	7.5	10	12
Mineral phenolic	0.8	0	..	..	..	..	..	..
Rag phenolic	0.7	0.1	0	..	..	..	..	..
Wood-flour phenolic	0.2	0	..	..	..	..	..	..
Transparent phenolic	0.2	0	..	..	..	..	..	..
Mineral alkyd	1	1	0.8	1	1	1	0.5	0
Alpha-cellulose melamine	1	1	0.2	0	..	..	..	..
Asbestos melamine	1	1	0.9	0	..	..	..	..

An average value of the tracking times was calculated for a material whenever the fraction effective was 0.5 or less. Such values are included in Figs. 2 and 3.

This study provides proof of the troublesome fact that in many cases a simple comparison of materials with regard to arc resistance cannot be made even for a single type of discharge. All the materials in Fig. 3 are consistently more arc resistant than the phenolics, under these test conditions. However, it will be noted that there are two possible criteria for judging materials and that one may not rank materials in the same order as another. The most usual

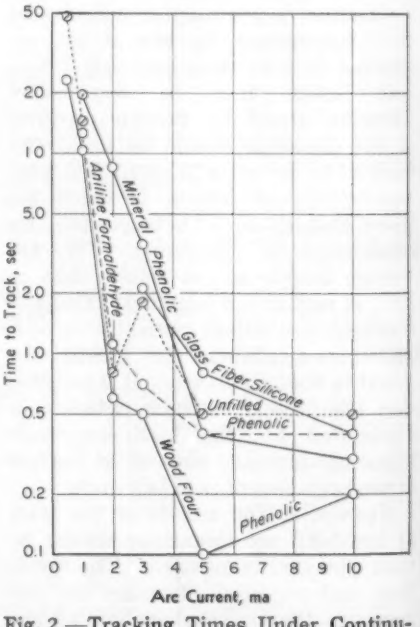


Fig. 2.—Tracking Times Under Continuous, Low-Current, 60-cycle Arcs for Less Resistant Materials.

is the time to failure under a given current; the second is the minimum current at which a material will track. None of the materials in Fig. 3 tracked at arc currents below 2 ma. Asbestos melamine and mineral alkyd failed to track consistently until currents of 5 and 12 ma, respectively, had been reached. In Fig. 2 the silicone was nontracking up to 3 ma, and only wood-flour phenolic and diced molding board phenolic (not shown) tracked at 0.5 ma. Several curves cross indicating that the order of materials depends on arc current. Conspicuous as examples of the latter are the superiority of the ureas over the cellulose melamines at higher currents and the reversal in position of mineral alkyd with respect to asbestos melamine and the ureas.

When the upward inflections of the urea and cellulose melamine curves were first noted, experimental error was suspected. The values for the two urea specimens were checked at 7.5 and 10 ma and confirmed the original data. It is thought that the factors responsible for this effect involve the relative rates at which carbon is formed and removed by arcs at different values of current. The erosion by the arc of carbon residues in urea and melamine materials has been described in a previous paper (2).

The sharp breaks in the curves for transparent phenolic and wood-flour phenolic are assumed to be due to experimental error, since the phenolic materials are particularly sensitive to changes in the condition and sharpness of the electrodes. In addition the speed of phenolic tracking is in many cases so rapid that accurate measurements with a stop watch cannot be assured. A comparison with data obtained by the standard ASTM method reveals that at no current is the order of materials the same as for the standard test and that, aside from increasing tracking time, the method of interrupting a 10-ma arc during early minutes of the standard test does not in fact simulate a continuous arc of lower current. Needless to say, only experience can justify the validity of a particular order.

It may be of interest to compare the dispersion of data obtained in this experimental test with the ASTM method. The stepwise nature of the latter test eliminates much variability by tending to confine values to small increments slightly exceeding the 1-min intervals of the test. Where constant conditions are imposed no discontinuities are present to influence the values obtained. Frequency polygons plotted from the data for two specimens of alpha-cellulose urea I tested at 2 ma are shown in Fig. 4. The number of observations in the two sets are 100 and 136. Since the values of each set were obtained by consecutive measurements on one specimen, these values were undoubtedly influenced by heating of the sample and electrodes and by any other effect which continuous testing of one material can have on the electrodes. However, the shape of the distribution (revealing a positive skewness) is probably characteristic of many materials. These and other similar observations, together with the fact that low values are usually more significant than high in judging arc resistance, suggest that the geometric mean would seem preferable to the arithmetic mean as a statistic in comparing materials for which the spread of values is large.

Tracking Under High Current Pulses:

If organic materials are exposed to arcs of several amperes or more for any length of time, so much damage is done that little discrimination among materials is possible. However, for many applications in electrical power insulation, it is desirable to learn something of the relative abilities of such materials to withstand high current arcs. One solution consists in exposing materials to short pulses of high current. The simplest method of generating such pulses employs a condenser connected to a d-c supply through a suitable resistance. The electrodes shunt the condenser and the arc pulses at a rate principally dependent on the time constant of the supply circuit. This circuit is only qualitatively useful because, as the sample degrades, the breakdown voltage of the electrode gap decreases and the repetition rate of the pulses of arc current increases rapidly. In addition any inductance in the circuit causes a damped oscillation during the pulse.

The circuit shown in Fig. 1(*b*) was devised to overcome the disadvantages of the simple condenser discharge circuit and also to make possible the measure-

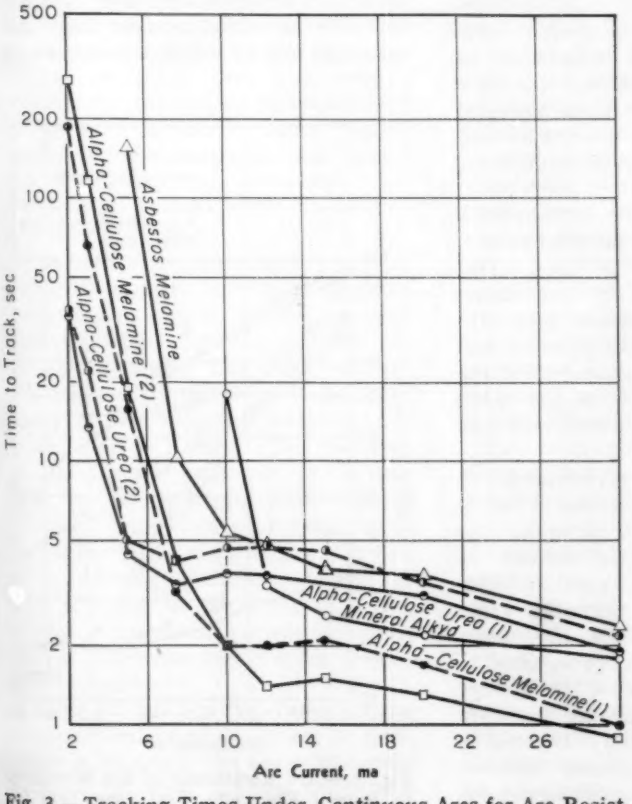
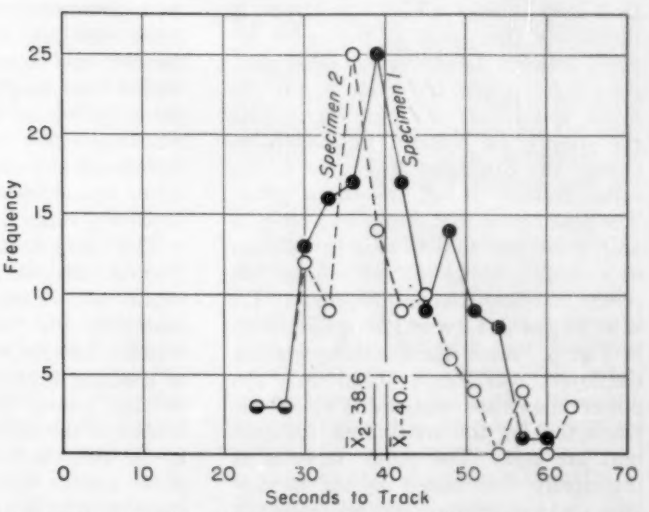


Fig. 3.—Tracking Times Under Continuous Arcs for Arc-Resistant Materials.



Specimen 1—136 obs.; Specimen 2—100 obs.; cell mid-points, seconds: 24, 27, 30, etc.

Fig. 4.—Frequency Polygons for Two Specimens of Alpha-Cellulose Urea Tested at 2 ma.

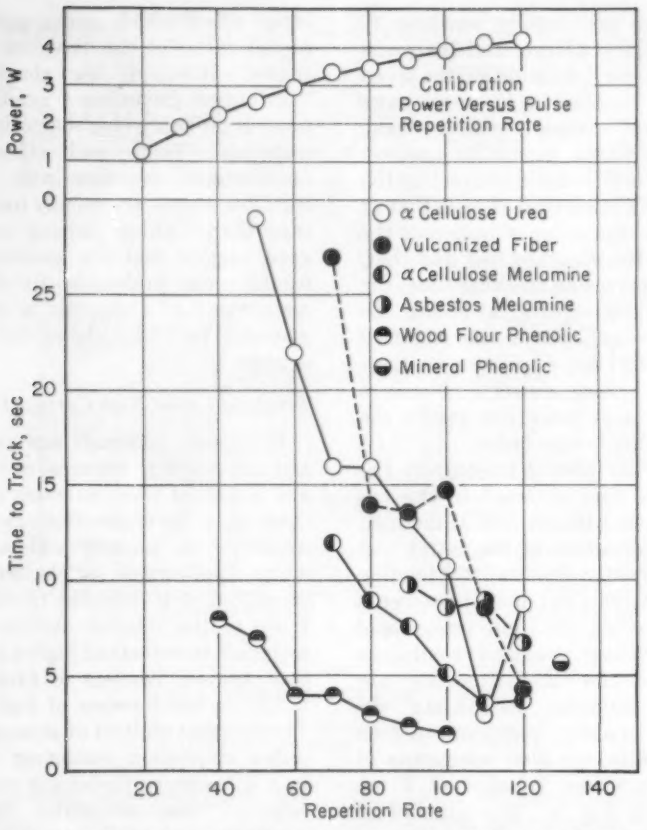


Fig. 5.—Tracking Times for Six Materials Under Pulse Arc Discharges.

ment of arc current and power. The high voltage thyratron (677) served as a switch and rectifier allowing only unidirectional current flow. The 884 thyratron pulse generator could be adjusted to produce positive pulses to fire the 677 at any fixed rate between 10 and 140 pulses per second. The inductance served both to limit the current and to shape the pulse into a half sine wave which facilitated the calculation of power.

The efficiency of the circuit is so low that very nearly all of the power is ultimately dissipated in the series resistor between d-c supply and condenser. As a consequence the value of this resistor could not, without overloading the supply, be reduced sufficiently to permit the condenser to charge to the same voltage at all repetition rates. The peak arc current decreases from 8.75 amp at 20 pps to 3.55 amp at 130 pps as a result. However, the average arc power increases from approximately 1.2 w at 20 pps to 4.2 w at 120 pps as shown in Fig. 5. Since the electrode spacing employed was again 0.125 in., the powers shown are comparable with those estimated for the continuous low-current arc test. The pulse duration is principally determined by the inductance and capacitance and was constant at 208 microseconds over the range of pulse rates employed. Pulse energy at all repetition rates was determined using a specimen of asbestos melamine conditioned to withstand the highest power input. A plot of arc voltage *versus* current was obtained from an oscilloscope calibrated for arc voltage. Peak currents were measured independently. Graphical integration on the basis of an assumed half sine wave for the current wave form provided values of pulse energy which were converted to average powers by multiplying by the repetition rate.

Five observations of time-to-track were obtained for each material at each pulse rate at which it failed. Dispersion, as measured by the range, varied considerably between materials, being poorest for the two phenolics and vulcanized fiber but acceptable for the melamines and urea (poorest case of the latter was asbestos melamine: 120 pps, mean 6.8, range 4.

The comparative performance of various materials is illustrated in Fig. 5. Again two criteria can serve to rate materials: the minimum current at which a material will track and the order of tracking times at a particular value of arc power. Although the many breaks in the curve are not assumed to to be reliable because of variability, some similar inflections are probably characteristic of materials in this test as in the continuous current method. Since no variability was observed for alpha-cellulose melamine at 110 pps, the short tracking time at this point may be indicative of a particular sensitivity of the material to a certain value of input power. A discussion of such behavior follows in a later section. It will be noted that although alpha-cellulose urea can track under arcs of lower power than the similar melamine, at higher powers the urea withstands the arc longer.

The behavior of the mineral-filled phenolic is noteworthy in two respects. Although at 110 and 120 pps single failures occurred in the five observations, this material did not track consistently until the highest power input available was reached. In addition, if this material was exposed to a lower power input before testing at 130 pps, no failures could be produced, indicating that surface resin had been removed exposing the more resistant mineral filler. The same characteristic was noted for asbestos melamine and enabled the use of a conditioned specimen as a non-tracking material for calibration of the equipment. Specimens of glass-filled silicone and mineral alkyd were included in the study and proved non-tracking over the range of powers available.

Raised Electrode Test:

If the electrodes are raised 0.012 in. from the surface of the test specimen, the somewhat reduced heating effect would be expected to cause a relatively small increase in tracking time. Such is the case for alpha-cellulose urea and melamine and for asbestos melamine, of

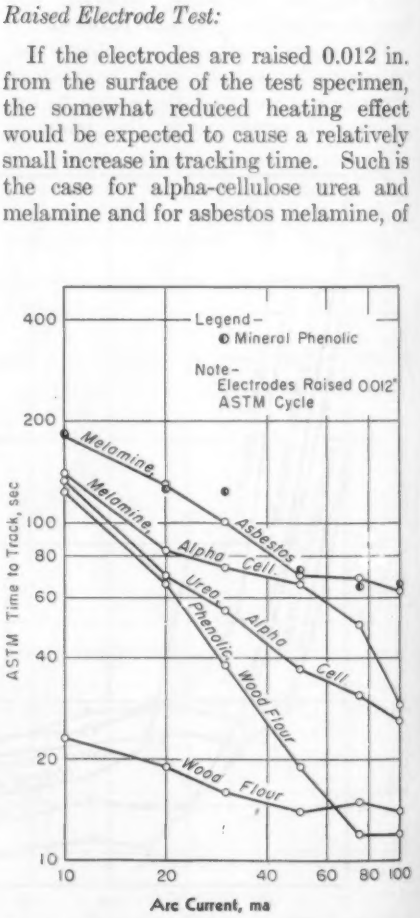


Fig. 6.—Arc Resistance of Six Materials in Raised Electrode Test (see text for details).

which the first two increase from standard test values of 128 and 130 sec to 133 and 140 sec, respectively. The increase for the asbestos material is negligible. The behavior of phenolics is noteworthy by contrast.

In Fig. 6 are plotted the tracking times for the raised electrode condition of six materials under varying values of arc current. In this test the arc was interrupted at all values of current according to the schedule specified for the first 4 min of the standard ASTM method. It will be noted that the arc resistance of wood-flour and mineral phenolics is increased from typical standard values of 2 and 8 sec to 123 and 185 sec and that this improvement holds over the range from 10 to 100 ma, particularly for the mineral-filled material. A probable explanation for these effects has been given in an earlier paper (2).

Compressed disks of wood-flour and alpha-cellulose fillers were included in this study, although the latter material is not shown in Fig. 6 to avoid confusion. Only nominal increases in the tracking times of these materials result from raising the electrodes. The poor arc resistance of wood-flour filler is worth noting, since alpha-cellulose filler is considerably superior (120 sec, ASTM D 495–48 T) and in general follows the alpha-cellulose urea plot in Fig. 6.

Power and Energy Considerations:

Since the order of materials in an arc-resistance test varies with the nature of the test conditions and type of discharge produced, one may inquire whether the value of arc power required to promote tracking varies significantly between methods. At present the available data concerning this question are limited to the continuous and pulse arc studies.

For both tests minimum values of arc power sufficient to cause tracking prove unexpectedly similar, despite the completely dissimilar character of the discharges involved. The continuous arc test employs alternating currents of the order of milliamperes requiring arc voltages up to 2000 v. The discharge produced in the pulse arc circuit consists in discontinuous unidirectional pulses of current with peak values up to 8 amp flowing at arc voltages as low as 60 v. Although the average powers for both arcs are in the order of watts, average power during periods of current flow in the pulse test reaches several hundred watts.

Table VI lists observed ranges of the minimum values of arc power or volt-amperes at which the seven materials common to both studies will track under either discharge.

TABLE VI.—MINIMUM VALUES OF POWER OR VOLT-AMPERES REQUIRED TO PRODUCE TRACKING ON SEVEN MATERIALS.

Material	Continuous Arc, volt-amperes	Pulse Arc, watts
Phenolic		
Wood-flour	0–1.0	1.8–2.3
Mineral	1.0–1.9	4.2–4.3
Melamine		
Alpha-cellulose	1.9–3.2	3.0–3.3
Asbestos	4.2–6.0	3.5–3.8
Urea		
Alpha-cellulose	1.9–3.2	2.3–2.7
Silicone		
Glass fiber	3.2–4.2	>4.3[a]
Alkyd		
Mineral	7.7–9.5	>4.3[a]

[a] No failures occurred in pulse arc test.

Knowledge of the effect of fillers is not sufficient to provide a quantitative explanation of the above data, nor are the values given reliable enough to permit basing any quite tentative conclusions thereon. However, the results justify some comment. In this connection, because of the nonunity power factor of the pulse arc, true power will be assumed to be somewhat less than the volt-ampere values listed (for assumed sinusoidal current and square wave voltage, the power factor is close to 90 per cent).

The minimum tracking power for the two alpha-cellulose filled resins is approximately equal in both tests. On the other hand, at least twice as much power is required in the pulse arc to produce failure in both phenolics as in the continuous current test. Although this may be due either to a lower heating efficiency of the pulse method or to a more erosive effect of the latter, it is suspected that the unidirectional arc current is responsible. The cathode spot appears to play a part in the early initiation of tracking in phenolics under a-c arcs, although rapid track growth is the result of a greater mobility of the anode spot. High-speed photographs of melamine tracking under pulse arcs reveal a unidirectional progress similar to that observed under continuous d-c arcs. Since this behavior is probably also characteristic of phenolics, in tracking of the latter under unidirectional arcs any track-initiating function of the cathode spot is absent.

The comparative behaviors of the mineral-filled materials do not reveal a consistent effect, except that mineral fillers raise the tracking power of both phenolics and melamine to a greater or lesser extent. While glass fiber silicone and mineral phenolic require appreciably higher power to track in the pulse test, the asbestos melamine is, if anything, more resistant to the conditions of the continuous current arc. Probably an important property of a mineral filler leading to higher tracking power is its greater thermal conductivity. Particles of filler may also serve to interrupt or terminate the growth of incipient tracks. In addition to those characteristics presumably common to all mineral fillers, asbestos may give rise to other effects resulting from its fibrous nature. The latter characteristic may in some cases counteract its beneficial properties by serving as a supporting network which can render areas of carbonized residues less susceptible to the erosive action of the arc. Observations of tracking on asbestos melamine support this proposition, since tracks on this material show less evidence of pitting and interruption of the carbonized path than alpha-cellulose filled resin. However, all mineral fillers probably permit the conditioning of materials to withstand indefinitely higher arc powers than the minimum tracking value as a result of removing surface resin at low power. In addition to observations of this phenomenon in connection with the pulse arc studies, it has been found that asbestos melamine can be gradually conditioned to withstand 9 volt-amperes or more in the continuous current test. This is a significant increase although its practical value is somewhat doubtful since other properties in the area of heat treatment can be assumed to have deteriorated considerably.

In the light of the above comments, the results of Table VI seem qualitatively comprehensible except for the asbestos melamine which appears to require somewhat more power for tracking in the continuous current test than under pulses. Since the ranges observed will allow an equal power of approximately 3.8 w in both tests, the data are not conclusive and no further speculation on this point is justified.

Tracking is evidently a function of arc power and time. The product of these two variables calculated at each of the test currents provides a measure of the energy input to the arc necessary to produce tracking. The data for the pulse arc test are too limited to be useful in this regard, but values for the continuous arc have been computed for four of the better materials and are shown in Table VII.

For each material the tracking energy reaches a minimum at a power level several increments higher than the minimum tracking value. It is significant that, at least for the four materials tabulated, over a considerable range of arc current above the minimum energy value the tracking energy is sufficiently constant to be considered a fundamental characteristic useful in the comparison of materials. Within this range minor variations occur in the tracking energy which are similar for the materials shown. However, since the

TABLE VII.—APPARENT ENERGY TO TRACK UNDER ARCS OF INCREASING CURRENT IN VOLT-AMPERE-SECONDS.

Arc Current, ma.....	2	3	5	7.5	10	12	15	20	30
Melamine									
Alpha-cellulose I.....	595	277	95	25	19	22	27	27	23
Asbestos.....	....	....	940	79	51	51	50	59	54
Urea									
Alpha-cellulose II....	120	93	30	32	45	52	58	56	50
Alkyd.....	....	....	....	...	170	36	33	35	41
	Volt-Amperes at Listed ma								
	3.2	4.2	6.0	7.7	9.5	10.8	12.7	16.1	22.6

physical basis of such variations is not known and timing uncertainties are present it is the general constancy of the values which is most noteworthy. At even higher powers it seems reasonable to believe that tracking energy must again increase since tracking time would not be expected to decrease to zero and at higher currents greater initial carbonization must take place to carry the current.

An earlier calculation of tracking energy from the data plotted in Fig. 6 indicated the possibility of a trend to higher tracking energy as the arc current increased. However, these calculations were based upon approximate powers in arcs from 10 to 100 ma listed in ASTM Methods D 495–42[4] and D 495–48T which have since been proved inaccurate (4). There is nevertheless a definite indication that there is at least one and perhaps two levels of arc power at which the arc energy consumed in the initiation of the track goes through a minimum. At these points the breakdown process is most efficiently promoted. At levels below the lowest minimum, energy is presumably lost through thermal conductivity. At higher powers the necessity for more extensive decomposition and perhaps increased erosion of carbonized material increases the energy required for tracking.

Conclusions

The time required to initiate tracking in the standard arc-resistance test depends upon the nature of the gases employed as the test atmosphere. Hydrogen, nitrogen, and helium give rise to an apparent increase in arc resistance compared to air values, the effect being particularly noteworthy for helium. The substitution of an atmosphere containing 5 per cent chlorine results in a considerable reduction in tracking time for all materials; however, this effect disappears as the concentration of chlorine is reduced to 1 per cent. Arc resistance is found to decrease with increasing specimen temperature, the rates of decrease varying somewhat among materials.

Studies of tracking behavior under continuous a-c arcs at currents as low as 0.5 ma reveal that there are minimum values of arc power below which materials will not track. These values differ among materials and can serve as an alternate to tracking time for comparing arc resistance. The order of tracking times of the materials tested is found to depend upon the level of arc current or power employed.

The results of arc-resistance tests under pulse discharges show effects similar to those noted for the continuous arc studies. In spite of the very different nature of the two discharges, it is found that the same order of power is required to promote tracking in both tests. Power is found to be a more fundamental parameter in causing tracking than arc current and makes possible comparisons between tests in which arc currents may differ widely.

Certain levels of arc power or current appear most efficient in causing tracking. A calculation of the energy input to the arc up to the start of tracking at various power levels in the continuous arc test reveals that, over an unexpectedly wide range of arc current, tracking energy varies only slightly. The data indicate that above and below this range greater energy is consumed in initiating the track. The approximately constant amount of energy which the tracking process requires over a considerable range of current seems then to be a minimum value and is possibly a fundamental property the value of which differs among materials. The search for the physical basis for these effects might well serve as a starting point for a more extensive investigation of arc resistance.

Tests designed to provide approximate values of the minimum tracking power and the minimum tracking energy (which may occur at considerably different current levels) require many times the labor of tracking time measurements such as the ASTM Method. Although this fact will probably preclude the use of the former for routine purposes, the results of the more extensive studies do indicate the need for caution and discrimination in the interpretation of standard test data and may suggest supplementary test methods when, for critical applications, tracking time data are inadequate.

Acknowledgment:

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(2) M. Olyphant, Jr., "Arc Resistance: (I) Tracking Processes in Thermosetting Insulating Materials," ASTM Bulletin, No. 181, p. 60, April, 1952.

(3) S. Whitehead, "Dielectric Breakdown of Solids," Oxford University Press (1951).

(4) Communication from G. R. Radley, April 24, 1951.

For more extensive bibliographies see References 1 and 2.

[4] Standard Method of Test for Arc Resistance of Solid Electrical Insulating Materials (D 495 – 42), 1946 Book of ASTM Standards, Part III-B, p. 121.

Efflorescence*

By F. O. Anderegg[1]

SYNOPSIS

Efflorescence is regarded by some as simply an annoying, more-or-less temporary, and superficial manifestation that occasionally appears on masonry walls. By others, the phenomenon is regarded as a symptom of what may be a serious disintegrating disease. It may be relatively fugitive when some of the soluble contents of the materials used in construction are brought to the surface. These may be removed by the first rain or may remain on the surface permanently, but harmlessly, as far as integrity of the masonry is concerned. At times serious disintegration of masonry is evident. An analysis is given of the factors contributing to efflorescent phenomena. Some of them may also participate in failures of protective coatings over materials other than masonry.

EFFLORESCENCE is a deposit of soluble salts, usually white in color, appearing upon the surface or found within the pores of a masonry structure. It is most obvious in the winter but may be observed throughout the year following heavy rains and drops in temperature. A special case is lime dissolved as hydroxide and brought to the surface mostly when new masonry construction has become saturated (Fig. 1). This hydroxide, being exposed to the air, soon carbonates and forms minute crystals of low solubility but of high light diffractivity. The crystals tend to obscure any other color but white. Otherwise they may hardly be regarded as harmful.

Another special case is the "cement bacillus"[2] formed by the action of sulfates on the hydrated calcium aluminate in hydrated portland cement. The double salt so formed, calcium sulfoaluminate, occupies far greater space than the original single aluminate (Fig. 2). Moreover, it can undergo crystal growth, so that it exerts two sorts of expansive force which are apt to be very disruptive to portland-cement products. After prolonged contact with water, the sulfate seems to separate again and be leached away. Petrographic examinations made by Dean S. Hubbell and the author (unpublished) have correlated the age of certain concrete pavements with the size of these crystals up to a period which depended upon the porosity of the pavement. Thereafter, these crystals seemed to be disappearing. Other observations of the contribution of sulfates have been reported by the author.[3]

A third special case is listed here because it involves soluble compounds producing disruption of concrete masonry: alkali silicates formed by the action of alkalies (apparently also including lime) on opaline sands and certain aggregates of volcanic origin. These silicates often collect in pockets, and the osmotic pressure produces disruptive action.[4]

Table I lists salts that have been found in efflorescent deposits and their solubilities in cold and warm waters.

SOURCE OF EFFLORESCING COMPOUNDS

As a result of a large number of analyses,[5] it can be stated that soluble salts are frequently found in most of the original materials used in masonry construction, mostly as sulfates:

1. Stone and washed natural sand may be essentially free of water-soluble salts, although where sea water has been used in washing an aggregate, sodium chloride and other salts may contribute to efflorescence.

2. Limes are essentially free of solubles other than calcium hydroxide.

* Presented at the Fifty-fifth Annual Meeting of the Society, June 23–27, 1952.

[1] Consulting Specialist on Building Materials Research, Somerville, N. J. This treatise was prepared at the request of the Efflorescence Subcommittee of C-12 on Masonry Mortars. The phenomena discussed are also important to C-18, Natural Building Stones; C-15, Masonry Units; C-9, Concrete; C-1, Cement; and D-1, Paint.

[2] W. Michaelis, "The Cement Bacillus," *Engineer*, Vol. 54, p. 22 (1892).

[3] F. O. Anderegg, "The Mechanism of the Corrosion of Portland-Cement Concrete with Special Reference to the Role of Crystal Pressure," *Proceedings*, Am. Concrete Inst., Vol. 25 (1929).

[4] Willard H. Parsons and Herbert Insley, "Observations on Alkali-Aggregate Reaction," *Journal*, Am. Concrete Inst., April, 1948 p. 625.

[5] Anderegg, Peffer, Judy, and Huber, "Indiana Limestone I. Efflorescence and Staining," *Bulletin 33*, Purdue University Engineering Experiment Station (1928).

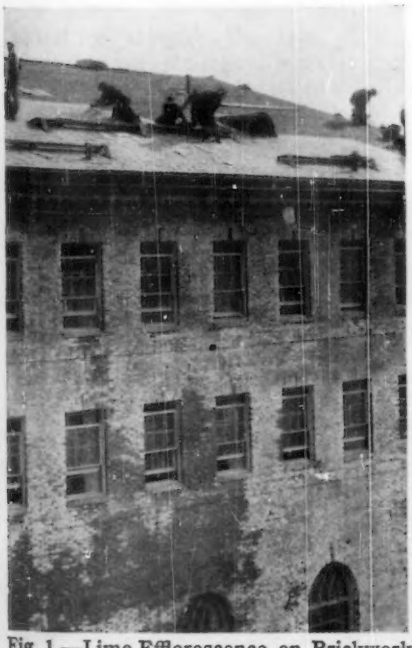

Fig. 1.—Lime Efflorescence on Brickwork Which Had Become Saturated During Erection.

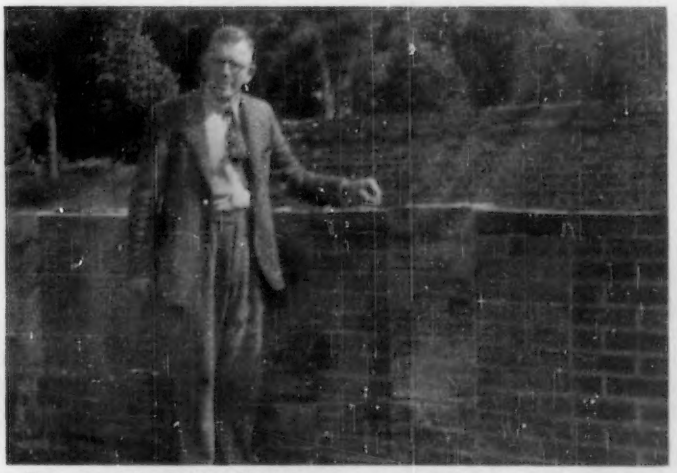

Fig. 2.—Dr. Bonnell of the British Building Research Station Indicates Brick Panel Where Gypsum from the Bricks Has Caused Panel Expansion.

TABLE I.—SOLUBILITIES OF EFFLORESCENT COMPOUNDS.

Compounds of:		Solubility, in g per 100 ml of Water, g	
		Cold	Hot
Calcium	Carbonate $CaCO_3$	0.0015 at 25 C	0.0019 at 75 C
	Chloride $CaCl_2 6H_2O$	deliquesces	
	Hydroxide $Ca(OA)_2$	0.19 at 0 C	0.08 at 100 C
	Nitrate $Ca(NO_3)_2 4H_2O$	deliquesces	
	Sulfate $CaSO_4 2H_2O$	0.24 at 0 C	0.22 at 100 C
	various silicates	very low	
Magnesium	Carbonate $MgCO_3$	0.011 at ..	.. at ..
	Chloride $MgCl_2 6H_2O$	deliquesces	
	Hydroxide $Mg(OH)_2$	0.0009 at 18 C	0.004 at 100 C
	Nitrate $Mg(NO_3)_2 6H_2O$	42 at 18 C	58 at 90 C
	Sulfate $MgSO_4 7H_2O$	71 at 20 C	91 at 40 C
	various silicates	very low	
Potassium	Carbonate $K_2CO_3 2H_2O$	129 at ..	268 at 100 C
	Chloride KCl	35 at 20 C	57 at 100 C
	Nitrate KNO_3	13 at 0 C	247 at 100 C
	Sulfate K_2SO_4	7 at 0 C	24 at 100 C
	various silicates	soluble	
Sodium	Carbonate $Na_2CO_3 10H_2O$	13 at 0 C	42 at 100 C
	Chloride KCl	36 at 0 C	39 at 100 C
	Nitrate $NaNO_3$	73 at 0 C	180 at 100 C
	Sulfate $Na_2SO_4 10H_2O$	11 at 0 C	93 at 30 C
	Vanadate $Na_3VO_4 16H_2O$	very soluble	
	various silicates	soluble	

3. Alkalies in varying amounts in portland cement may contribute to efflorescence either as sulfates or as the hydroxide, which soon turns to carbonate, and some of the lime set free on hydration may also migrate to the surface and carbonate.

4. Ceramic units, depending upon the nature of the raw material and the degree of burning, may contribute soluble salts.

5. Natural stones, from contact with ground water, all contain at least traces of such salts.

Efflorescences resulting from many of these salts tend to appear early in the life of the structure and are usually relatively fugitive. Lime changing to carbonate is more permanent; salts found in certain ceramic units may make their appearance quite slowly.

One of the continuing sources of troublesome efflorescence is the ground when it is in capillary contact with masonry structures. Such structures will continue to accumulate soluble salts at a rate dependent upon the magnitude and continuity of the capillary system of both the soil and the construction and upon weather conditions. Even such dense stones as granites, Fig. 3, and marbles are subjected in varying degree to efflorescent action.[6] To prevent all capillary contact with the ground requires proper materials carefully applied and is often more difficult than is usually appreciated. The wick action of masonry in contact with ground results in the continuing accumulation of salts within a few feet of the contact. This means that old basement walls are likely to contain large amounts of salts, both below and above grade.

Another very troublesome source of efflorescent material is rain water, Fig.

[6] Arthur Hockman and Daniel W. Kessler, "Thermal and Moisture Expansion Studies of Some Domestic Granites," *Journal of Research*, Nat. Bureau Standards, Vol. 44, 1950, (*RP* 2087).

Fig. 3.—Granite Disintegrating Due to Efflorescent Action.

Fig. 4.—Mortar Full of Sulfates from Rain Penetration. Note mortar debris on box.

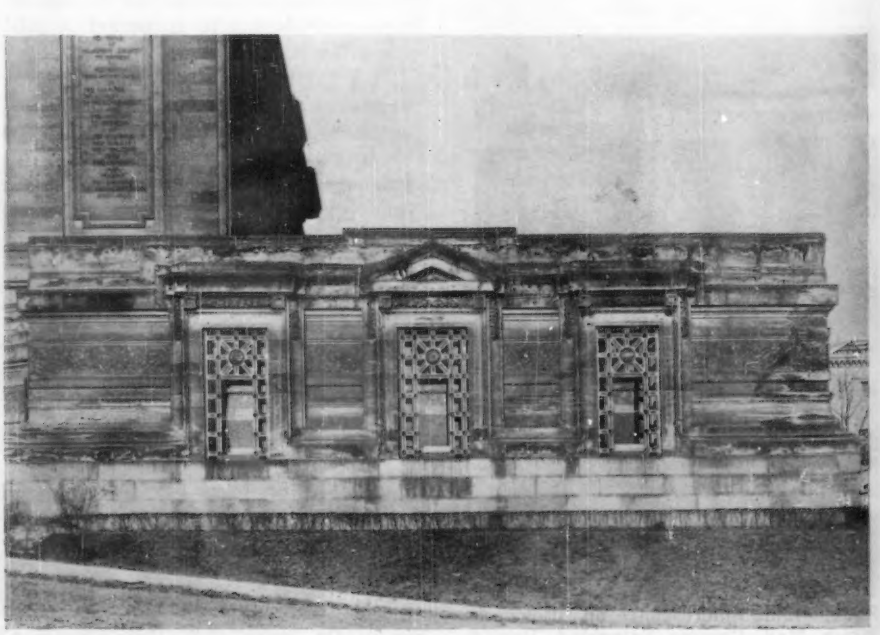

Fig. 5.—Sandstone Copings Have Permitted Rain Penetration.

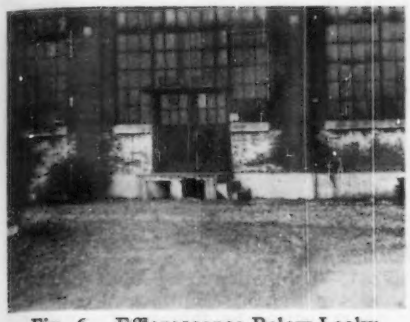

Fig. 6.—Efflorescence Below Leaky Window Sills.

4. Analyses[6] have shown considerable amounts of sulfur acids in rain water. In the Summer these may be more-or-less neutralized by calcareous dusts; but in Winter the rains are quite corrosive, at least in the northeastern part of this country. Any rain water getting into a masonry structure through the innumerable openings found between units and mortar[5] brings in a bit of acid to form calcium, magnesium, or alkali sulfates. These salts often accumulate with time, and the older the buildings the greater is the amount present.

In areas along the ocean sea salts blown in by storms are sources of efflorescent material. Such troubles are experienced along our Atlantic coast and in Europe.

The Role of the Water in Efflorescent Action

Water is the solvent for the soluble, efflorescence-producing salts. It serves as the vehicle by which they are transported to the surface where they accumulate as the water evaporates. Water promotes solution and recrystallization; the little crystals grow into large ones.

In addition to entrance from the ground or through the face of the masonry walls, considerable water gets into the wall through copings (Fig. 5), window sills (Fig. 6), and stone belt courses (Fig. 7). To avoid such ingress, all such architectural details should be provided with flashing underneath, which should come not merely to the surface, but should definitely extend outward and downward about an inch to form a drip.

Fig. 7.—Stone Trim Improperly Used.

Much moisture also enters masonry wall as vapor from the interior and accumulates there as it condenses. This action is more insidious and far reaching than is generally realized.

Without water in the wall, there would be no trouble from efflorescent action. If the moisture that is so apt to get in could be rapidly removed, a large part of the present troubles would be avoided. Moisture can be eliminated from a wall by drainage and by evaporation. Continuous within-wall cavities with weep holes at the bottom are extremely useful.[7, 8] They not only permit excess water to drain away, but they also provide (Fig. 8) internal ventilation to hasten the evaporation.

If such internal ventilation is not provided, it is very important to do nothing to interfere with the breathing of the wall. The old timers said that "a masonry wall must breathe." Hard-burned ceramic units with glazed surfaces reduce the transpiration of moisture from the surface and may contribute to the production of a condition favorable for accentuated efflorescent action. Water sufficient to freeze may

[7] F. O. Anderegg, "Watertight Brick Masonry," *Arch. Record*, September, 1931. "Watertight Terra Cotta," *Journal*, Am. Ceramic Society, Vol. 16, p. 634 (1933).

[8] Harry C. Plummer and Leslie J. Reardon, "Principles of Brick Engineering," p. 147, Structural Clay Products Inst., Washington, D. C., 1943. Ben Small, "Cavity Wall Construction," *Progressive Arch.*, August, 1947, p. 66.

Fig. 8.—Church Built of Handmade Brick with Cavity Wall, in 1842, Shows No Signs of Efflorescent Action.

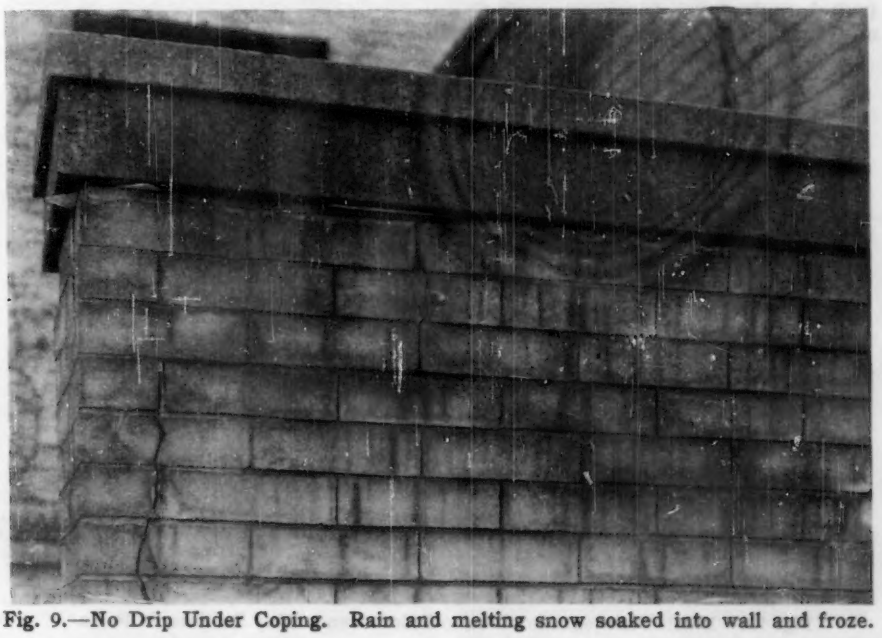

Fig. 9.—No Drip Under Coping. Rain and melting snow soaked into wall and froze.

Fig. 10.—Blisters of Water May Accumulate Where Adequate "Breathing" Is Prevented.

accumulate in pockets in the wall and cause cracking of the wall as shown in Fig. 9. At other times, the water will promote corrosion of structural steel, which results in expansion and cracking of the masonry.

The application of protective coatings over a masonry wall to form continuous films of low vapor transmission rate is likely to be very injurious to the health of the wall. Some of the newer plastic emulsions seem to have the ability to permit quite good breathing. Before any surface application is applied to masonry, an experiment should be carried out to see whether it will interfere with breathing. This can be done quite simply.[9]

Laws of Solutions and Efflorescence

A knowledge of the so-called "colligative properties" of solutions which form efflorescence is quite pertinent in understanding efflorescent phenomena. These colligative properties include the effect of the concentration of the solution on osmotic pressure, vapor pressure lowering, and freezing point lowering.

Concentration increases as moisture evaporates and raises the osmotic pressure. There is a force driving any water in the masonry toward the surface where the solution has become concentrated by evaporation. Where a masonry surface has been covered with a paint film, the osmotic pressure tends to form blisters and forces the applied film off bodily, Fig. 10. It is suggested that in addition to raising ground water to the tops of the tallest trees, this mechanism, to which the soluble salts are a contributing factor, may also be a similar factor in the blistering of paint applied to wood. These colligative properties vary with, but increase faster than, the concentration.

Damp spots often appear on cellar walls and other enclosed spaces where high humidity may occur. The common reaction is that the wall has leaked. The moisture from the atmosphere has condensed, and where soluble salts are present, condensation is increased due to vapor pressure lowering. If the

[9] F. O. Anderegg, "Testing Surface Waterproofers," ASTM Bulletin, No. 156, January, 1949, p. 71. Also "Results on Testing Surface Waterproofings," *ibid*, No. 171, January, 1951, p. 48.

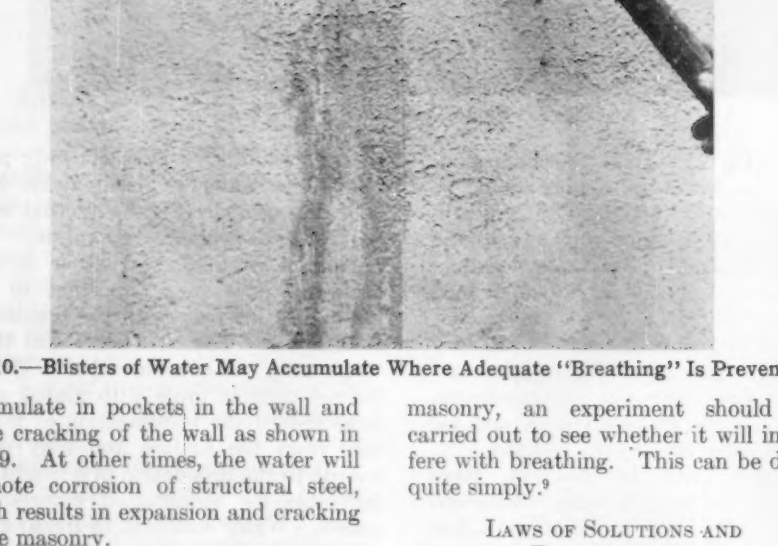

Fig. 13.—Much Disintegration Due to Efflorescence May Be Seen in Paris.

Fig. 11.—Exfoliation by Sodium Sulfate Crystals of the Brick Surfaces Rendered Water Repellent by Silicone Treatment. It takes an unusual combination of conditions to produce this effect.

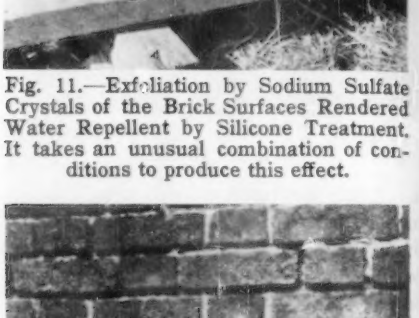

Fig. 12.—When the Lime Mortar in This Old Masonry Wall Disintegrated, Some of the Joints Were Repointed With Cement Mortar. Then the adjacent bricks began to deteriorate, because the mortar was now stouter and denser than the bricks.

salts have become concentrated, damp spots can be seen. Of course, condensation may occur generally over a cellar wall in damp weather in the Summer, the high heat capacity and heat conductivity of the wall being important contributing factors. Condensation of any water permeating a surface film by vapor pressure lowering may contribute to blister formation.

The effect of the salt concentration on freezing point lowering is probably less important, but under certain conditions may resist freezing of water and actually give some protection to the wall against the resultant hydraulic pressures.

The Laws of Crystal Growth

The laws of crystal growth are very important with reference to efflorescent crystal pressure. In the first place, the molecular forces involved in their growth are great, of the order of 100,000 psi or more. Many crystals, especially sulfates, grow in certain oriented directions more readily than in others. Changes in moisture content and in temperature and the rates at which they occur profoundly affect the crystal growth habit and the size which they may reach. These influences tend to cause the growth of elongated sulfate crystals, and when they continue to grow within a confined space they exert pressures too great for masonry materials to withstand, Fig. 11. Of course, the stronger the material, the better it will resist efflorescent crystal pressure. But when rocks as stout as granites undergo disintegration by this mechanism, what about our other masonry materials?

Materials of low porosity, or having discontinuous pores, will last longer by slowing down the movement of these solutions. Often masonry materials are weak because they are porous, their strength apparently being proportional to the density and inversely proportional to the pore space. For these two reasons dense materials resist efflorescent disintegration better, but the improvement is only relative.

The effect of temperature on the efflorescence is of interest. If the temperature drops very slowly, the crystals also grow quite slowly on a comparatively few nuclei, so that there is formed a smaller number of comparatively large crystals which produce great aggregated pressure. The author has developed an accelerated test for the resistance of building materials to disintegration:

A 20 per cent solution of sodium sulfate is placed in a pail provided with at least 6 in. of mineral wool insulation. The dry specimen to be studied is immersed in the solution, which is then placed in a refrigerator running at, say, 0 F. After one week, the pail is opened and found to be full of well-developed crystals ranging from ¼ to ½ in. The insulation is removed from the pail and it is warmed to dissolve the crystals. It takes a very rugged material to withstand a dozen cycles of this treatment, especially when the specimen is dried between immersions. Often atmospheric conditions promote slow crystal growths and help develop high pressures.

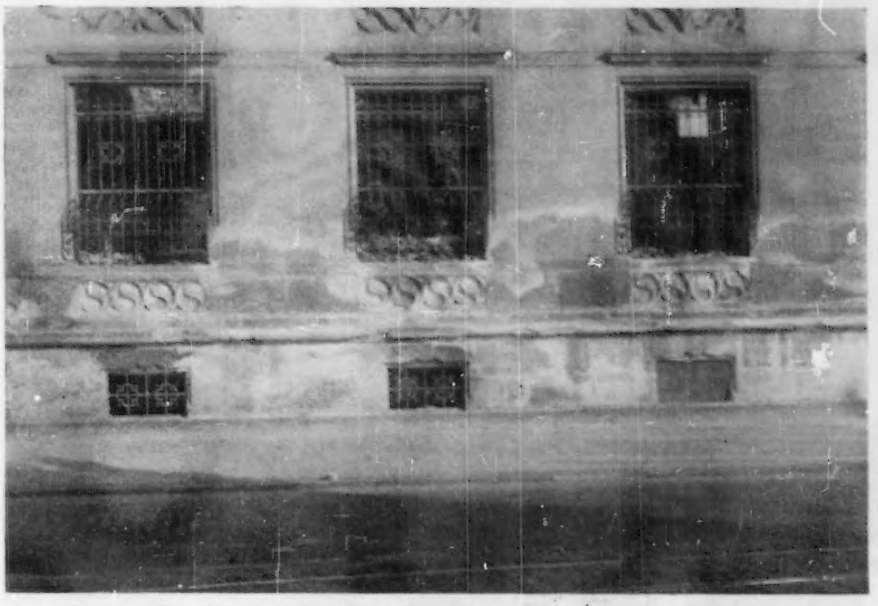

Fig. 14.—The Germans Also Have Troubles. They sometimes use the word "*Mauerfresser*" or "Masonry devourer."

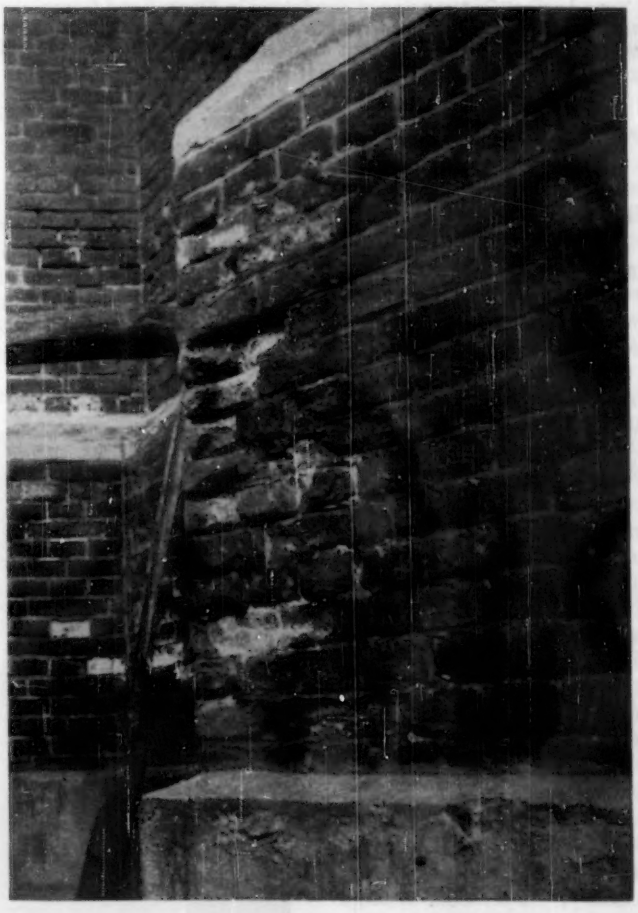

Fig. 15.—Cathedral of Breda, Holland.

In a masonry wall, any temperature changes in the ambient air are slowed down by the high heat capacity of the wall, which encouraged the oriented crystal growth of dissolved salts. Evaporation rate is also a factor, the slower the evaporation the better the oppor-

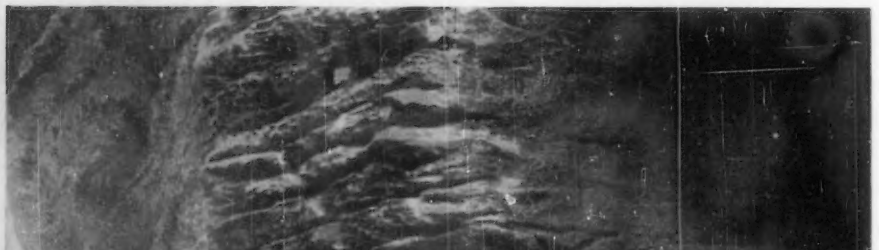

Fig. 16.—A Very Ancient Outcropping of Sandstone in Black Hand Gorge, Licking County, Ohio, Greatly Disintegrated by Efflorescent Crystal Pressure. The salt deposit seen on the surface is mostly calcium sulfate. Much more is found in the pores behind the surface.

tunity for oriented growth. Surface treatments that reduce breathing seem to promote crystal growth. They are, however, likely to be very deleterious to the integrity of the masonry.

It is suggested that any treatment to the surface that tends to build up a crust, especially where an appreciable amount of soluble salts has accumulated, will aid exfoliation as a consequence of efflorescent crystal pressure developing just behind that crust, Fig. 11. In certain calcareous systems, including limestones and cement products, the tendency of dissolved calcium bicarbonate or lime changing to carbonate, as evaporation proceeds, will aid in building up such a crust and favor spalling.

Where a surface layer of masonry has been rendered water-repellent, as by treating with certain silicone solutions, any salts already present in the masonry will accumulate just inside the water-repellant region and may cause exfoliation, Fig. 11. Where water-repellent surface coatings of cement or mortar have been applied over masonry containing soluble salts, similar spallings have been observed.

In old masonry, the presence of large accumulations of soluble salts makes proper additional protection quite difficult. Some good may be done by first wire-brushing the surface and then washing down at intervals of a week or so to permit the water that has penetrated the wall to bring the salts to the surface as drying takes place. A systematic study should be made to find the best method to use in removing the accumulation of soluble salts often found in old masonry.

Trouble can be anticipated with porous basement walls, where excessive wetness occurs, which may have resulted from improper grading around the house or failure to drain off downspout water. A little carelessness with these details often gives much trouble.

One method which has been found useful in preparing a concrete surface for painting should be useful in reducing the solubilities of the salts present. Burnett and Fowler[10] have found that when a solution of 2 per cent zinc chloride plus 3 per cent phosphoric acid is flowed on a concrete surface, it can be painted after drying with greatly increased freedom from blistering or saponification. A study is being made of the possibilities of such a treatment applied to a basement wall of cinder blocks, where efflorescent crystal pressure has pushed off considerable areas of a cement-base waterproofer.

In Winter, efflorescence is generally much more prominent than in Summer. In the first place, Winter rains contain higher concentrations of sulfur acids to form more salts. The wall may be soaked by a driving rain or snow melting and seeping downward through copings, window sills, and stone belt courses which have not been adequately flashed.

At the conclusion of the storm, the temperature frequently drops and the surface of the wall becomes chilled by contact with colder air and by giving up the heat required by any water evaporating. The solubility of most of the salts present falls, the solution becomes saturated, and crystals start to grow. The increase in concentration raises the osmotic pressure, probably more rapidly than any temperature drop would tend

[10] G. E. Burnett and A. L. Fowler, "Painting Exterior Concrete Surfaces with Special Reference to Pretreatment," *Journal*, Am. Concrete Inst., Vol. 18, No. 6, June, 1947, p. 1077.

Fig. 17.—The Face of a Sandstone Quarry in Black Hand Gorge After About 30 yr Exposure Was Coated with Calcium Sulfate Efflorescence in the Spring of 1951.

to lower it. Lowering of the temperature and increase in concentration tend to condense any vapor formed within the interior of the walls into the pores near the surface. The surface tension is also increased so that larger pores may become filled. As evaporation proceeds, the soluble salts are precipitated in a ring around each pore. The ring continues to grow outwardly into a tube. The author has seen such tubes, in areas protected against drafts, as long as 8 in. The composite result of all these factors seems to be to produce more apparent efflorescence following Winter rains than during warmer months.

It is generally realized by those who have made a careful study that most masonry disintegration is caused by efflorescent crystal pressure. In the aggregate, in this country alone, this may amount to millions of dollars in damage every year. Britain,[11] Fig. 12, and most other parts of Europe, Figs. 13 to 15, are having similar troubles. Every attention should be given to those details which will reduce the penetration of rain water and ground moisture to a minimum. In addition, care should be taken to provide an escape mechanism, such as a continuous cavity within the walls with weep holes suitably placed to get all moisture out as quickly as possible by drainage and ventilation. Efflorescent disintegration may be seen on many natural rock outcroppings as shown in Figs. 16 to 18. Efflorescence seems to be a potent mechanism of breaking down rocks.

Fig. 18.—Even Famous Monuments, Such as the Lucerne Lion, Carved Out of a Sandstone Cliff, Are Not Immune to Efflorescent Disintegration.

[11] D. G. R. Bonnell and W. R. Pippard, "Some Common Defects in Brickwork," *Nat. Building Studies, Bull. No. 9*, His Majesty's Stationery Office, London (1950).

Discussion of the Paper on Cleaning of Steel Test Panels for Paint[1]

MR. R. R. ROGERS.[2]—This article is of considerable interest to us because we feel that the importance of properly treating the test panels prior to coating can hardly be overestimated.

We agree that the sanding or abrading of test panels would not give satisfactory results. The same is true of dipping in solvent and then wiping with rags saturated with solvent.

After a considerable amount of investigation we have adopted the following procedure for treating new steel panels and those which already have been used:

1. Remove any grease or oil which may be on the surface of the panels by degreasing in trichlorethylene or by any other efficient method.
2. Blast the panels with No. 30 fused alumina grit at a pressure of 35 psi until all nonmetallic material has been removed and the surface has a uniform appearance.
3. Immediately thereafter scrub the panels thoroughly with a bristle brush while immersed in trichlorethylene liquid.
4. Immediately thereafter treat the panels in a trichlorethylene vapor degreaser.
5. Wrap the panels in clean white paper while still warm from the degreaser.
6. While still warm, store the wrapped panels in a desiccator until required for coating.
7. Coat the panels as soon as possible, certainly not more than three days after they have been placed in the desiccator.

Being an artificially produced material, fused alumina grit does not vary materially from batch to batch. It does not shatter nearly as readily as ordinary sand. Any fine particles of fused alumina or steel are removed from the surface by the scrubbing in trichlorethylene liquid and rinsing in the vapor degreaser. Moist air has little opportunity to reach the surface of the panel before it is stored in the desiccator.

At first sight this procedure may appear to be very complicated. However, once the proper equipment had been obtained, it has not been found to be particularly difficult. Since its adoption we have been well satisfied with the results obtained.

MR. THOMAS RICE (*Author's Closure*).—I have not had the opportunity to try the procedure Mr. Rogers recommends.

However, it would appear that the alumina blasting would cause an abrasion of the panel surface, which he states would not be satisfactory.

Also, members of Group 1 on Preparation of Steel Test Panels for Paint have found that dry polishing with lintless cloth is necessary to obtain panels free from smudge, regardless of how thoroughly the panels have been previously cleaned either by vapor degreasing or by solvent spraying. Furthermore, several of the group members have found that a dip in methanol has always improved the panel surfaces as judged by the various cleanliness tests described in the paper.

[1] Thomas Rice, "Cleaning of Steel Test Panels for Paint," ASTM BULLETIN, No. 178, December, 1951, p. 50 (TP 244).

[2] Dept. of Mines and Technical Surveys, Ottawa, Canada.

A Statistical Analysis of the Mechanical Properties of Cast and Wrought Gold Dental Alloys*

By S. H. Bush[1]

SYNOPSIS

A statistical analysis was carried out on certain mechanical properties of cast and wrought gold dental alloys. Data obtained from manufacturers' charts were considered, as were data determined experimentally.

Linear correlations were found for proportional limit and tensile strength, proportional limit and Brinell hardness number, and tensile strength and Brinell hardness number. These correlations are given in graphical form, together with the 5 per cent limits of error.

The most satisfactory relationship was found to be for proportional limit and tensile strength. A pronounced scatter was noted when Brinell hardness number was considered. It is felt that control of such factors as heat treatment and the method of conducting the mechanical tests would reduce the scatter to a marked degree. This is supported by the experimental results.

Such data are subject to statistical analysis, and such analyses should detect abnormal behavior in gold alloys.

INVESTIGATIONS have shown that definite correlations exist among such mechanical properties as hardness, yield strength, and tensile strength in various steels (1).[2] Likewise, Tabor (2,3) has determined a similar relationship for the non-ferrous materials, and he postulated that such relationships should exist for all plastic metals.

A previous investigation (4) reported a linear correlation between any two of these properties, but results were based on only four manufacturers' products covering twelve compositions. Linear relationships were found to exist between tensile strength and diamond pyramid hardness, proportional limit and tensile strength, and proportional limit and diamond pyramid hardness. However, the values covered a limited range, so it was believed that a consideration of the manufacturers' data would prove of interest. As a result, the mechanical properties appearing on the physical properties charts prepared by nine different dental gold manufacturers were considered. The properties investigated consisted of Brinell hardness number, proportional limit, and tensile strength for both cast and wrought gold alloys.

No definite correlations have been reported for this group of alloys, but work at the National Bureau of Standards (5) has indicated that such might be the case for a few of these alloys. The present study covers a wide range of alloy composition, and further variables are the production and test methods of the various manufacturers. Therefore, it is felt that any definite correlation observed would be fundamental to the gold alloys.

With this in mind, analyses of correlation were made to determine the regression lines. Analyses of variance and significance tests were also conducted, plus a determination of the standard deviation of the dependent variables from the regression lines.

MATERIALS

The experimental results were described in a previous report (4). A total of twelve alloys was investigated and twenty-five tests were made. These alloys were furnished by the following companies:

Handy and Harman, Chicago, Ill.
J. M. Ney Co., Hartford, Conn.
Spyco Smelting and Refining Co., Minneapolis, Minn.
The S. S. White Dental Manufacturing Co., Philadelphia, Pa.

The statistical analysis of the values reported by the manufacturers was based on a maximum of 226 conditions for the evaluation of proportional limit *versus* tensile strength. Since the data on Brinell hardness were not available for all products, only 156 conditions were used in the comparison of proportional limit *versus* Brinell hardness number and Brinell hardness number *versus* tensile strength. Listed below are the manufacturers together with the number of alloys of each that were checked:

Julius Aderer, Inc., New York, N. Y. (17)
Baker and Co., Inc., Newark, N. J. (17)
Handy and Harman, Chicago, Ill. (7)
J. F. Jelenko and Co., New York, N. Y. (12)
J. M. Ney Co., Hartford, Conn. (18)
Spyco Smelting and Refining Co., Minneapolis, Minn. (13)
I. Stern and Co., Inc., New York, N. Y. (9)
Vernon-Benshoff Co., Pittsburgh, Pa. (10)
The S. S. White Dental Manufacturing Co., Philadelphia, Pa. (16)

The results used were those appearing in the manufacturers' literature. It may be assumed that average values are reported, but nothing is known concerning the prior history of these alloys. No attempt is made to identify the products, since it is not the purpose of this report to differentiate between manufacturers' values.

ANALYSES AND TEST METHODS

The mechanical properties of the experimental alloys, as well as the procedures used in their determination, were discussed in a previous report (4). These tests consisted of the determination of proportional limit and tensile strength of the wires, together with the hardness values, which were determined with a Vickers hardness tester using a 136 deg diamond pyramid point. The diamond pyramid hardnesses were converted to Brinell hardness numbers by means of a conversion chart based on metals softer than 240 Brinell (3). It is realized that such a conversion is subject to some error, but this was deemed necessary in order to permit a comparison between the hardness-tensile relationships determined experimentally and those reported in the manufacturers' literature. However, the work of Tabor (2) indicates that the Brinell or Vickers numbers are essentially the same, in this hardness range.

The statistical analysis of the data consisted of a determination of the regressions of proportional limit upon Brinell hardness number, Brinell hardness number upon proportional limit, proportional limit upon tensile strength, tensile strength upon proportional limit, tensile strength upon Brinell hardness number, and Brinell hardness number upon tensile strength, for both the experimental and manufacturers' data. Both regressions were carried out since it was felt that the properties were of

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

* This study was aided by a contract between the Office of Naval Research, Department of the Navy, and the University of Michigan.

[1] Instructor, School of Dentistry, University of Michigan, Ann Arbor, Mich.

[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

TABLE I.—MECHANICAL PROPERTIES OF DENTAL GOLD ALLOYS.

Tensile Strength, psi	Proportional Limit, psi	Brinell Hardness Number	Tensile Strength, psi	Proportional Limit, psi	Brinell Hardness Number	Tensile Strength, psi	Proportional Limit, psi	Brinell Hardness Number	Tensile Strength, psi	Proportional Limit, psi	Brinell Hardness Number
Manufacturers' Data											
48 000	24 000	100.0	53 000	27 000	105.0	56 000	33 000	128.0	86 000	55 000	189.0
70 000	50 000	148.0	113 000	85 000	249.0	68 000	45 000	137.0	113 000	85 000	243.0
113 000	77 000	175.0	154 000	125 000	270.0	83 000	53 000	175.0	140 000	113 000	265.0
83 000	63 000	145.0	140 000	116 000	235.0	52 500	27 000	...	64 400	31 900	...
52 500	30 000	...	64 400	36 000	...	63 400	41 000	...	104 700	74 000	...
69 200	46 100	...	112 400	75 400	...	114 500	74 400	...	153 400	117 600	...
108 300	63 600	...	150 500	107 500	...	110 000	60 000	...	173 500	110 000	...
111 000	62 000	...	172 500	112 000	...	97 200	68 000	...	158 600	119 400	...
137 100	93 800	...	144 500	95 800	...	92 400	63 000	...	130 400	110 600	...
91 600	60 000	...	123 300	91 000	...	78 000	49 000	...	135 500	90 000	...
100 500	64 000	...	136 000	100 000	...	100 900	63 600	...	119 000	81 000	...
50 500	85 300	...	79 000	126 400	...	101 000	61 100	...	124 300	84 000	...
55 000	24 500	110.0	65 000	32 000	140.0	59 500	30 500	105.0	62 000	32 500	120.0
74 000	41 500	145.0	117 000	78 000	215.0	67 000	41 500	137.0	112 000	94 200	220.0
123 000	84 000	...	175 900	133 700	...	108 000	78 000	...	156 000	127 000	...
119 500	90 500	...	187 000	136 400	...	108 000	73 500	...	168 000	110 000	...
90 000	53 000	...	132 000	100 500	...	87 600	53 000	...	150 000	111 000	...
52 000	19 500	88.0	80 300	42 200	125.0	57 000	23 700	93.0	52 000	25 000	105.0
60 000	30 500	115.0	51 000	24 000	110.0	63 000	28 000	120.0	86 000	53 500	175.0
115 000	65 000	220.0	65 000	37 500	155.0	117 500	81 000	225.0	148 000	115 000	225.0
167 000	134 500	260.0	117 500	86 500	190.0	173 000	131 500	270.0	125 000	88 000	175.0
178 000	135 000	275.0	120 000	89 000	180.0	180 000	148 000	280.0	110 000	63 500	150.0
170 000	127 000	270.0	120 000	73 000	200.0	165 000	135 000	290.0	100 000	52 000	160.0
157 000	122 000	265.0	125 000	80 000	200.0	58 000	27 000	100.0	81 000	40 000	135.0
86 500	50 000	150.0	115 000	85 000	190.0	170 000	130 000	270.0	60 000	24 000	95.0
85 000	46 000	130.0	63 000	30 000	105.0	52 400	27 600	110.0	64 300	32 500	130.0
51 000	29 000	110.0	59 000	35 500	126.0	65 300	41 600	143.0	112 000	79 600	241.0
63 000	34 000	128.0	124 000	90 000	230.0	132 000	102 000	...	186 000	151 000	...
104 000	76 000	...	143 000	107 000	...	89 000	57 000	...	122 000	84 000	...
114 000	74 000	...	166 000	138 000	...	82 000	54 000	...	130 000	103 000	...
84 000	53 500	...	142 500	103 000	...	140 000	96 000	...	174 000	133 000	...
116 000	87 000	...	133 000	107 000	...	86 000	43 000	...	89 000	44 000	...
87 000	56 000	...	100 000	73 000	...	60 000	33 000	...	66 000	37 000	...
51 500	21 000	...	54 000	20 700	...	69 000	41 000	137.0	112 000	82 000	230.0
80 000	46 000	133.0	115 000	100 000	263.0	65 000	30 700	111.0	100 000	45 600	170.0
55 500	22 600	89.0	135 000	93 500	192.0	167 000	133 000	265.0	108 000	63 000	170.0
166 000	120 000	270.0	100 000	77 500	204.0	125 000	86 000	242.0	100 000	65 000	171.0
157 000	110 000	264.0	97 000	57 000	155.0	157 000	100 000	285.0	86 500	53 000	138.0
140 000	105 000	255.0	100 000	60 000	152.0	138 000	102 000	239.0	89 100	57 000	157.0
146 000	102 000	278.0	48 000	28 500	114.0	57 000	43 000	147.0	67 000	41 000	138.0
102 000	73 000	229.0	67 500	44 000	138.0	108 000	88 000	238.0	83 000	52 000	175.0
116 000	67 000	220.0	86 000	54 000	169.0	102 000	82 000	220.0	104 500	70 000	150.0
150 000	122 000	238.0	112 000	77 000	195.0	174 000	153 000	294.0	81 500	51 000	152.0
141 000	111 000	229.0	121 000	90 000	195.0	164 000	136 000	294.0	105 500	73 500	175.0
161 000	126 000	232.0	111 000	86 000	175.0	163 000	131 000	248.0	110 000	77 000	195.0
159 000	127 000	238.0	120 000	84 500	152.0	184 000	140 000	248.0	104 000	73 000	195.0
149 000	130 000	229.0	125 000	87 000	172.0	177 000	157 000	285.0	145 000	124 000	229.0
183 000	151 000	245.0	50 000	25 000	95.0	55 000	29 000	108.0	53 000	28 000	103.0
56 500	30 000	105.0	70 000	45 000	142.0	108 500	84 000	210.0	72 500	48 000	138.0
124 500	100 000	217.0	120 000	79 500	190.0	177 000	144 000	284.0	115 000	80 500	185.0
171 500	139 000	287.0	86 500	53 500	154.0	142 500	118 000	245.0	96 000	59 000	138.0
143 000	123 500	221.0	113 000	78 000	180.0	165 000	130 000	265.0	96 000	59 500	150.0
170 500	148 500	280.0	50 400	27 200	88.0	52 000	33 000	112.0	60 000	37 500	135.0
65 000	39 500	150.0	103 000	72 000	225.0	136 000	87 000	176.0	181 000	136 000	240.0
114 300	85 000	178.0	164 600	133 000	230.0	104 600	74 000	168.0	154 500	118 000	251.0
97 100	68 300	162.0	158 900	124 600	270.0	71 700	38 000	126.0	124 300	99 000	208.0
108 400	63 300	172.0	127 700	96 900	273.0	...	...	...	...	...	...
Experimental Data											
114 800	72 400	225.0[a]	135 700	107 700	264.0[a]	111 500	69 200	218.0[a]	107 300	67 000	216.0[a]
163 800	129 300	284.0[a]	86 700	55 000	192.0[a]	130 700	101 400	261.0[a]	130 800	95 300	273.0[a]
167 800	129 600	334.0[a]	115 800	87 000	209.0[a]	152 800	128 200	305.0[a]	81 200	49 700	158.0[a]
129 200	92 500	275.0[a]	108 200	66 900	226.0[a]	135 700	100 700	261.0[a]	126 000	79 800	186.0[a]
142 200	107 800	232.0[a]	90 700	51 700	165.0[a]	140 500	97 800	270.0[a]	100 800	65 700	174.0[a]
128 500	94 800	251.0[a]	75 200	49 500	180.0[a]	112 700	84 900	240.0[a]	87 500	58 000	154.0[a]
115 200	89 300	231.0[a]	...	...	...	...	...	...	...	...	...

[a] Converted from diamond pyramid hardness.

TABLE II.—ANALYSES OF VARIANCE OF REGRESSION.

Variables	Class	Number of Samples	Variance Due to Regression (1)	Variance About Regression (2)	Ratio of 1 to 2	Degrees of Freedom	Significance Levels		Is Regression Significant
							5 per cent	1 per cent	
Proportional limit *versus* tensile strength	A	226	$272\,088 \times 10^6$	88.37×10^6	3080	224	3.84[a]	6.63[a]	Highly
	B	25	13 654	36.74	372	23	4.28	7.88	Highly
Proportional limit *versus* Brinell hardness number	A	156	186 831	219.20	852	154	3.84[a]	6.63[a]	Highly
	B	25	11 745	120.40	98	23	4.28	7.88	Highly
Tensile strength *versus* Brinell hardness number	A	156	206 338	234.40	881	154	3.84[a]	6.63[a]	Highly
	B	25	13 235	55.00	241	23	4.28	7.88	Highly

[a] For infinite degrees of freedom.

equal importance so neither variable could be considered to be wholly dependent on the other. The assumption was made that these regressions were linear; this is confirmed by the results. All relationships were given since it is felt that similar interests might not exist among all individuals.

The regression lines were determined by least squares analysis in the manner described by Davies (6). The regression analyses consisted of the regression of y upon x and the regression of x upon y where the first condition is defined by the equation:

$$Y = \bar{y} + b(x - \bar{x})$$

where Y is the predicted value of the dependent variate and $\bar{y}$ and $\bar{x}$ are the means of the y and x values.

The regression coefficient b is defined as:

$$b = \frac{\Sigma(x - \bar{x})(y - \bar{y})}{\Sigma(x - \bar{x})^2}$$

Similarly, the regression of x upon y is defined by the equation

$$X = \bar{x} + b'(y - \bar{y})$$

In this case

$$b' = \frac{\Sigma(x - \bar{x})(y - \bar{y})}{\Sigma(y - \bar{y})^2}$$

It is desirable to determine the analysis of variance of the regression since such an analysis will show the significance of the regression based on the variation due to the regression, and that about the regression. The variance due to the regression of y upon x is $b^2\Sigma(x - \bar{x})^2$ while that about the regression is

$$\sigma_r^2 = \frac{\Sigma(y - \bar{y})^2 - b^2\Sigma(x - \bar{x})^2}{N - 2}$$

where N is the number of specimens used in the regression.

Similarly, the variance due to the regression of x upon y is $b'^2\Sigma(y - \bar{y})^2$ while that about the regression is

$$\sigma_r'^2 = \frac{\Sigma(x - \bar{x})^2 - b'^2\Sigma(y - \bar{y})^2}{N - 2}$$

Since b is not equal to b', it follows that the slopes of the two regressions are not the same, nor are the variances about the regression, except in very limited cases.

The significance of the regression can be determined by applying the F test. The value of the variance due to the regression divided by the value of the variance about the regression will give some number. This number plus the degrees of freedom, which is equal in regression analysis to two less than the number of samples, will permit a comparison between the ratio determined and the significance levels at 5 and 1 per cent, which were used in this study. The significance levels can be found in most statistical tables. If the ratio exceeds these levels to any extent, the regression is definitely significant.

An analysis of variance for linearity should be carried out where there is any doubt as to whether the best fitting line is straight or curved. To do so, the data must be arranged in a frequency table to permit the determination of column means and residuals about the column means. Rider (7) and Brownlee (8) discuss such analyses of variance. The mathematical derivations as well as some examples are given by Rider.

Results

The statistical analyses of the data are presented in tabular form in Tables I, II, and III, and in graphical form in Figs. 1, 2, 3, 4, 5, and 6. The regression equations of combinations of any two of the three variables, proportional limit, tensile strength, and Brinell hardness number, are given in graphical form in Figs. 1, 2, 3, 4, 5, and 6.

Table I contains a listing of the mechanical properties of dental gold alloys as determined by the manufacturer together with experimental data determined in this laboratory. No attempt was made to subgroup these data by manufacturers, since initial studies indicated that no significant differences were noted with such subanalysis.

The analyses of variance in Table II indicate whether the regression is significant. Class A covers manufacturers' data, class B is experimental data. The variance due to the regression and about the regression was calculated as described in "Analyses and Test Methods," and the ratio determined was compared to 5 and 1 per cent significance levels for the designated degrees of freedom. Values were taken from a Table of F-Distribution in Davies (6), where the variance due to the regression had one degree of freedom and that about the regression had $N - 2$ degrees of freedom, where N is the sample size. Since the ratios of variance due to regression divided by the variance about the regression were much greater than the 1 per cent significance levels, the regressions all were significant.

In Table III the square roots of the variances about the regression are given. These values are known as the standard deviations, and they were multiplied by a factor based on the degrees of freedom to determine the 5 per cent limits of error. The factors were taken from a t-Distribution Table given by Davies (6). The 5 per cent limit indicates that 95 per cent of the values for specimens from the universe giving the regression observed will fall within the limits noted; 5 per cent will be outside these limits.

Discussion of Results

Figures 1, 2, 3, 4, 5, and 6 graphically represent the relationships observed for both experimental and manufacturers' data. Regressions of y upon x and x upon y were considered; for example, both proportional limit *versus* tensile strength and tensile strength *versus* proportional limit were considered, since opinions might differ as to which relationship is of greater interest. In the author's opinion, the most valuable relationships are given in Figs. 1 and 3, since it is possible to predict proportional limit from known values of tensile strength or Brinell hardness number, and these properties are the easiest to determine. If Vickers diamond pyramid hardness is used, a still better relationship is obtained. By selecting the correct graph, Brinell hardness number or tensile strength can also be predicted.

Limits of 5 per cent which, essentially, are equal to twice the standard deviation were selected since this limit has been accepted as satisfactory in many instances.

The relationships given on these graphs are valid over the range denoted by the solid lines, and no further. Any attempt to predict values by extrapolating these lines may lead to error. The range over which the values are satisfactory are set by the limits of the graph or the unbroken lines, and these limits plus the equations will permit the comparison of the data if the reader is interested in making such a comparison.

It will be noted that no points were plotted on the graphs. This was not done since it was found that the great number of points made the use of the graphs difficult, and any attempt to put selected values on the graph might lead to erroneous conclusions.

The various factors discussed have indicated that a definite correlation exists among the variables, and the regression is significant for both groups of data. This is particularly interesting when it is realized that a wide variation in chemical composition, production practice, and heat treatment probably has occurred, plus the fact that both cast and wrought alloys were considered in the analysis.

In any analysis such as has been conducted in this report an excessive scatter in the data is to be expected. This is not so apparent in the experimental results since the heat treatment as well as the mechanical testing was carried out so that the personal error

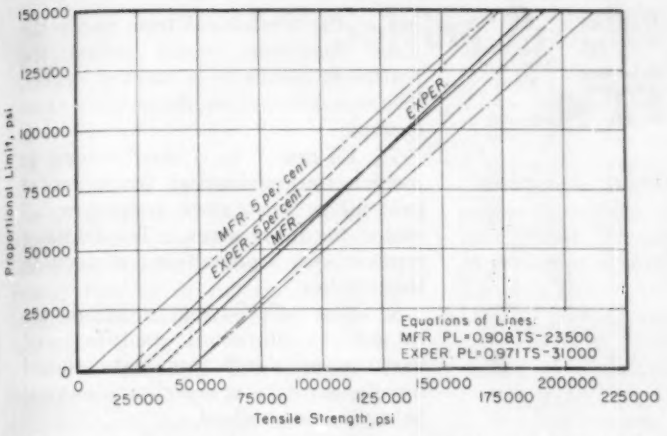

Fig. 1.—Relation Between the Proportional Limit and Tensile Strength of Dental Gold Alloys.

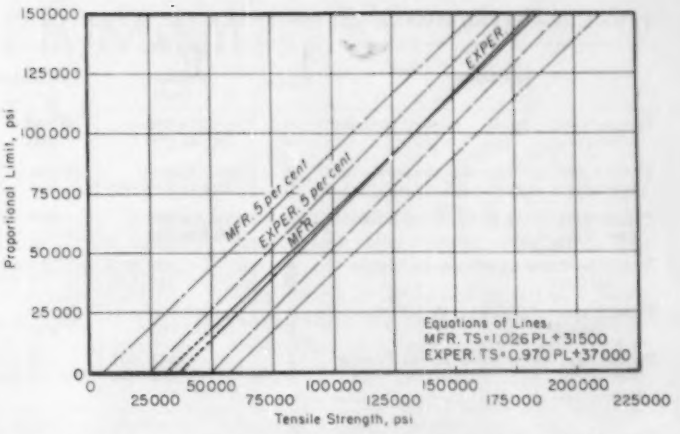

Fig. 2.—Relation Between the Tensile Strength and Proportional Limit of Dental Gold Alloys.

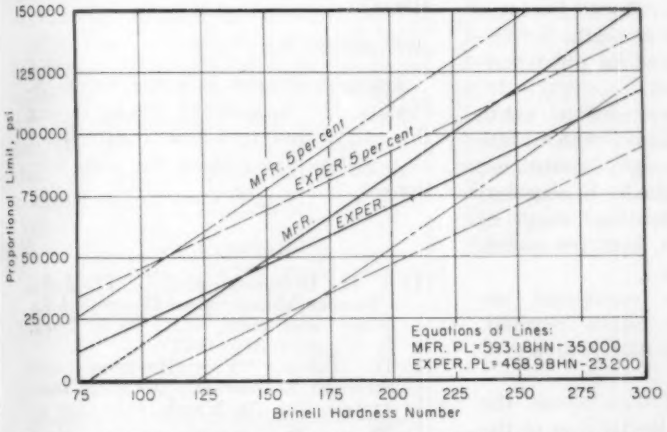

Fig. 3.—Relation Between the Proportional Limit and Brinell Hardness Number of Dental Gold Alloys.

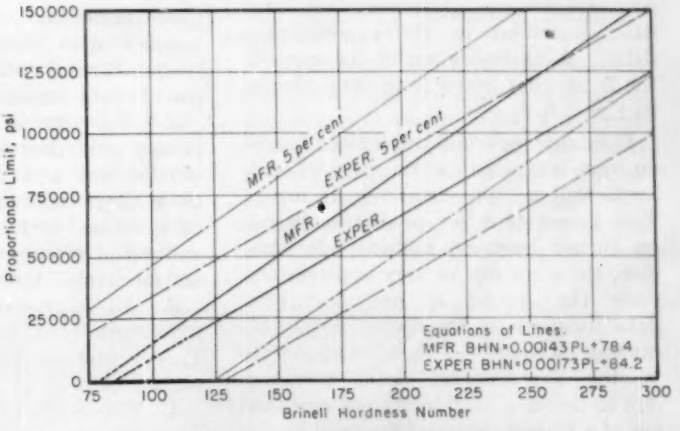

Fig. 4.—Relation Between the Brinell Hardness Number and Proportional Limit of Dental Gold Alloys.

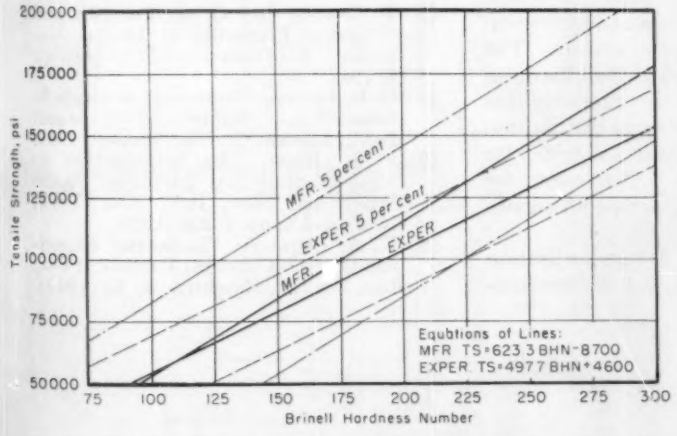

Fig. 5.—Relation Between the Tensile Strength and Brinell Hardness Number of Dental Gold Alloys.

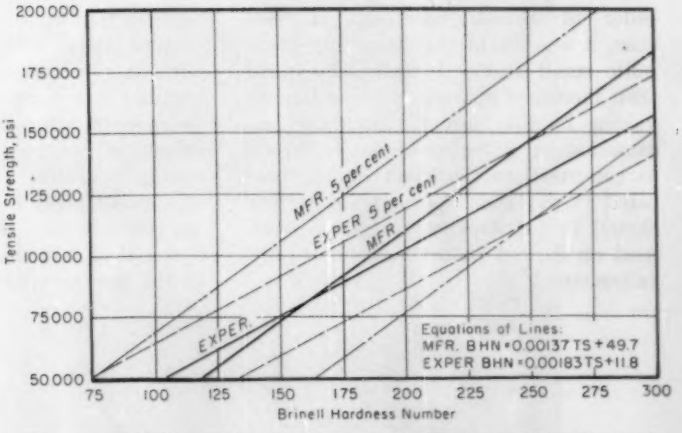

Fig. 6.—Relation Between the Brinell Hardness Number and Tensile Strength of Dental Gold Alloys.

TABLE III.—APPROXIMATE VARIANCE AND DEVIATION ABOUT REGRESSION LINES.

Variables	Class	Variance (σ_r^2)	Deviation (σ_r)	Degrees of Freedom	5 per cent Limits of Error
Proportional limit *versus* tensile strength	A	88 374 000	9 400	224	±18 400
	B	36 743 000	6 060	23	±12 500
Tensile strength *versus* proportional limit	A	109 832 000	13 030	224	±25 500
	B	35 043 000	5 920	23	±12 300
Proportional limit *versus* Brinell hardness number	A	219 204 000	14 800	154	±29 000
	B	120 384 000	10 970	23	±22 700
Brinell hardness number *versus* proportional limit	A	527.838	23.20	154	± 45.5
	B	443.165	21.05	23	± 43.0
Tensile strength *versus* Brinell hardness number	A	234 305 000	15 310	154	±30 000
	B	54 963 000	7 410	23	±15 300
Brinell hardness number *versus* Tensile strength	A	513.391	22.66	154	± 44.4
	B	202.550	14.23	23	± 29.5

was minimized. However, in the manufacturers' values a large number of variables can and probably did influence the results. When it is considered that the heat treatments undoubtedly differed, and the mechanical testing procedures also may have differed, it is obvious why a much more pronounced scatter is observed in the manufacturers' data compared to the experimental data. As an indication of the spread, the 5 per cent limits have been placed on Figs. 1 to 6.

It is apparent that predictions based on tensile values or on proportional limits will not be excessively in error. This is not true for prediction based on Brinell hardness number. In this case, the error can be very appreciable, since the spread in manufacturers' data increases as the Brinell hardness number increases. This is not apparent in the experimental data, possibly due to uniform heat treatment and the use of a Vickers diamond pyramid hardness test rather than a Brinell hardness test.

It was found that the limits of error could not be expressed properly for Brinell values, even with a corrected equation using grouped data. As a result, those data were divided into six groups of 26 values, with these values being consecutive in increasing order of Brinell hardness. In this case, it was found that the limits were quite small at low Brinell values and then increased sharply as these Brinell values became larger. However, an examination of the approximate limits, as compared to the exact limits, indicated that the approximate limits should be satisfactory, and these were used on Figs. 1 to 6 and are the only values noted.

Conclusions

1. A linear correlation exists for the regressions of proportional limit upon tensile strength, proportional limit upon Brinell hardness number, tensile strength upon proportional limit, tensile strength upon Brinell hardness number, Brinell hardness number upon proportional limit, and Brinell hardness number upon tensile strength, for the manufacturers' data and for the experimental data considered.

2. This linear correlation exists among gold dental alloys which were in the cast and wrought conditions; these alloys differ markedly in chemical composition and probably vary in method of production, heat treatment, and mechanical testing.

3. All regressions considered are significant over the ranges covered. This is obvious from the analyses of variance.

4. The scatter of data about the regression line is less in the case of the experimental data than in the case of the manufacturers' data. This is believed due to the fewer samples, narrower composition range investigated, and the standardization of the heat treatment and mechanical testing procedures.

5. While there are a large number of variables which may affect the published mechanical properties, it is still obvious that these values and the experimental data are very similar. The differences noted when Brinell hardness number is a variable are probably due to an assumption of normal distribution which is not confirmed by tests, for example, Table III. Correction for this might possibly eliminate all significant differences.

6. It is felt that a standardization of the heat treatment and the conducting of the mechanical tests under the same conditions would reduce the scatter in results to a marked degree. The experimental results are cited as an example.

7. Figures 1 to 6 can be used to predict the mechanical properties of gold alloys when these properties fall within the range given. The limits of error in such a prediction are given on these figures.

8. It is believed that such data are subject to statistical analysis, and variance or significance tests should serve as a means of detecting abnormal behavior in such alloys.

9. A standardization of the procedure to be followed in determining the Brinell hardness number of the gold alloys or, perhaps better, the use of the Vickers hardness tester, should reduce the scatter of the data, and such a procedure has been used in approximating the ultimate tensile strength or the proportional limit of the various gold alloys.

Acknowledgment:

Acknowledgment is made to F. A. Peyton for suggestions made during this study and to Clyde Ingersoll for his assistance in making the computations.

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Solving Problems in Materials*

By T. S. Fuller[1]

I SHALL attempt to outline the progress in materials which has contributed to the advancement of the Electrical Industry over the past fifty years, realizing of course that similar progress has been made in other industries.

The products of the electrical industry are configurations essentially of conductors, insulation, and magnetic circuits. With few exceptions the conductors are formed from copper and its alloys which we shall consider first.

Copper

Tiny coils are made from magnet wire having a diameter of 0.001 in. or less. Field coils, each weighing a ton, are made from bars having rectangular sections for turbine generators.

The only means of increasing the hardness and tensile strength of pure annealed copper is by deformation at a temperature below that of recrystallization (Fig. 1). The electrical conductivity is appreciably reduced by the presence of cold work (Fig. 2).

Copper is available to industry in grades known to the trade as "tough pitch" and "oxygen free," the latter commanding a small premium in price. Tough pitch copper normally contains oxygen in the neighborhood of 0.035 per cent (Fig. 3) and the oxygen-free metal, as the name indicates, is free from oxygen (Fig. 4).

The outstanding behavior difference between these two types of copper is the ability of the oxygen-free variety to resist embrittlement by "gassing," while the tough pitch metal is seriously damaged by this process.

Gassing:

When tough pitch copper is heated to temperatures above 350 C in the presence of hydrogen the metal becomes brittle. As mentioned previously, tough pitch copper contains 0.035 per cent oxygen. The oxygen is present mainly in the form of cuprous oxide particles distributed in the mass with a small amount of oxygen in solution. Hydrogen, a small atom, diffuses into the copper and there meets up with the oxides, reducing the latter, forming steam molecules. The tiny hydrogen atoms continue to diffuse into the copper, while the steam molecules, because of their size, cannot escape. The result is the building up of a pressure within the metal at grain boundaries sufficient to cause a separation of the metal at the boundaries (Fig. 5). The consequence, of course, is a copper which is mechanically brittle.

These facts are probably well known and it is unlikely that anyone skilled in the art would consider heating tough pitch copper in hydrogen. Evidence, however, points to the fact that many of us who should know do not realize what a small amount of hydrogen is sufficient to cause embrittlement, although this phase of the subject has been repeatedly stressed in the literature.

To illustrate, tough pitch copper was packed in clean sea sand in a seamless steel tube and was heated to a temperature of 800 C for 1 hr in an electrically heated furnace. The ends of the tubes were closed with iron plugs. The sample of copper, on being removed from the tube after cooling to room

* This lecture was presented by President Fuller at a number of ASTM District meetings held during the 1951–1952 season.

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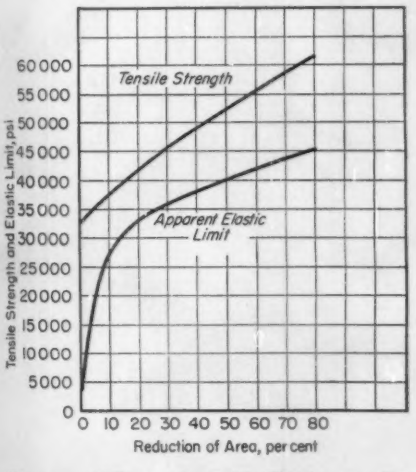

Fig. 1.—Effect of Cold Work on the Mechanical Properties of Copper.

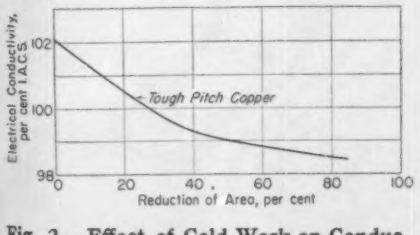

Fig. 2.—Effect of Cold Work on Conductivity.

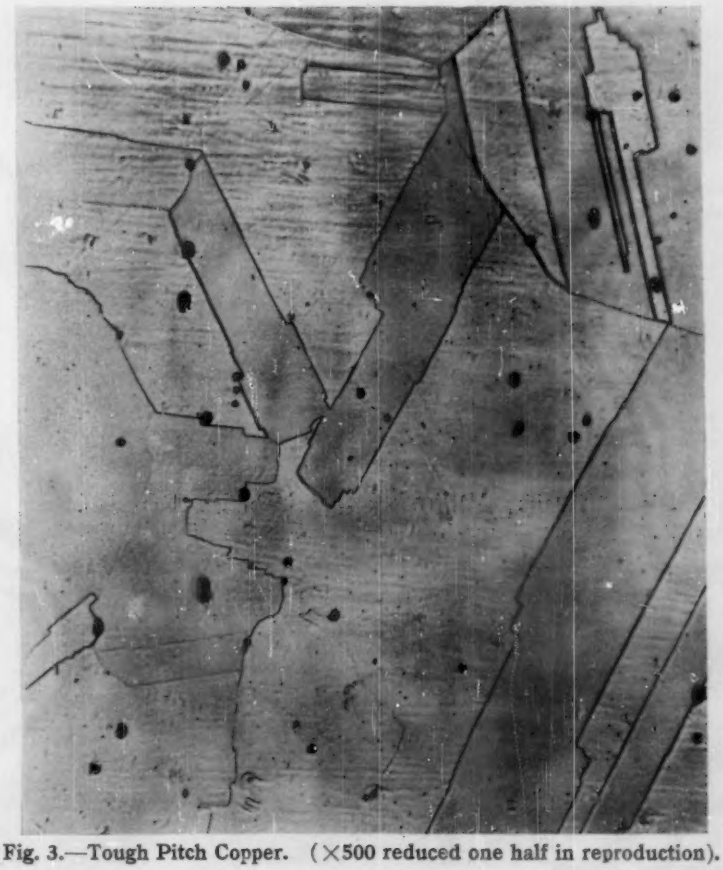

Fig. 3.—Tough Pitch Copper. (×500 reduced one half in reproduction).

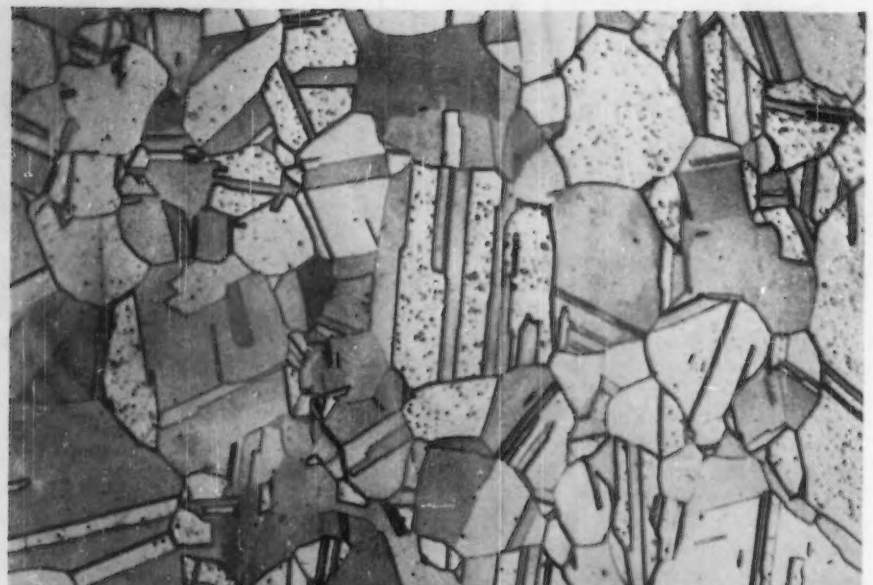

Fig. 4.—Oxygen-Free Copper (×250).

Fig. 5.—Hydrogen Effect on Copper (×250).

temperature, was found to be extremely brittle. Microscopic examination showed the open grain boundaries so characteristic of copper in the "gassed" condition. This result was unexpected and the question naturally arising was—what is the constituent associated with iron pipe or clean sea sand which could be expected to produce embrittling conditions when heated? Possibly organic matter on the surface of the sea sand might have been present in sufficient quantity when heated to result in an embrittling condition, and also there was the possibility of the reaction between water vapor present and the iron surface, resulting in a small amount of hydrogen. At any rate, whatever the source, the amount of embrittling atmosphere present under the conditions of the experiment must have been extremely minute.

Accordingly a sample of tough pitch wire from the same lot of copper previously used was packed in finely divided aluminum oxide in a porcelain tube and heated for 1 hr at 800 C. Wire, so treated, at the end of the experiment was ductile and showed no evidence under the microscope of grain boundary voids.

In the next experiment, copper from the same lot was packed in sea sand in a porcelain tube and heated for 1 hr at 800 C. This sample proved to be brittle and showed unmistakable evidence of gassing, justifying the conclusion that the sea sand was a source of embrittlement. When this experiment was repeated, using sea sand which had previously been ignited 4 hr in air at 600 C to remove any organic matter and water which may have been present, the copper specimens remained ductile, indicating that something on the surface of the sand had been responsible for the embrittling atmosphere when that material was used.

These experiments serve to emphasize the fact that a very small amount of hydrogen can, with the proper conditions, produce embrittlement of tough pitch copper. A case where such embrittlement has more or less frequently been found is brazed joints.

Such embrittlement can, of course, be avoided by the use of copper which contains no oxygen.

Copper with Silver and Cadmium:

Many current-carrying parts are subjected to vibration or moderate steady stress at mildly elevated temperatures. Designers, therefore, are interested in improving both the fatigue and rupture properties of copper. Such improvement, however, obviously must not seriously impair the conductivity.

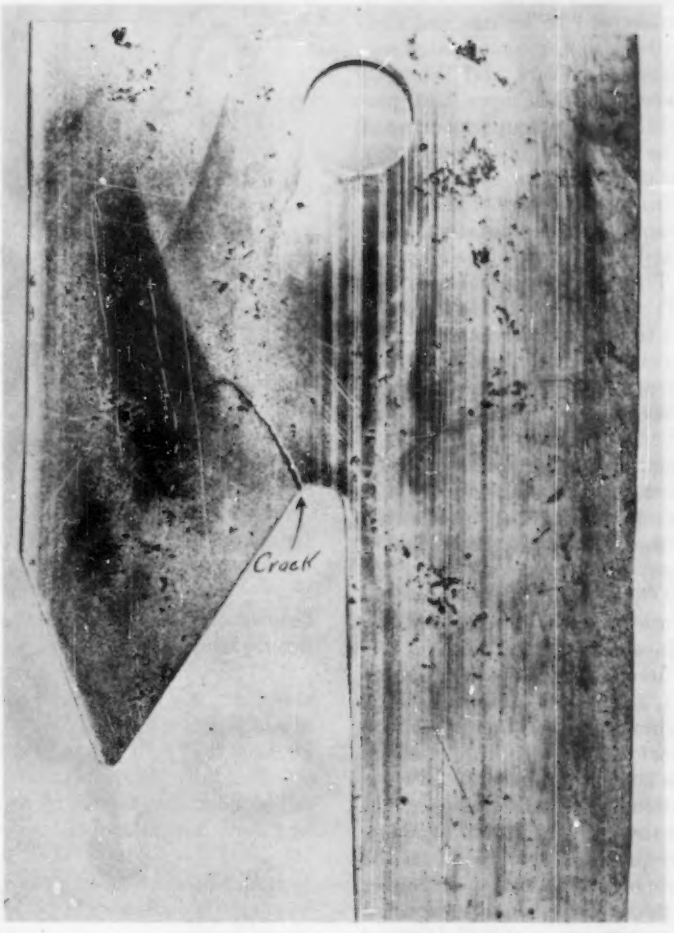

Fig. 6.—Commutator Failure.

S. Skowronski, of the Raritan Copper Refinery, meticulously prepared alloys of pure copper with the more common metals and determined the effect upon the conductivity of copper of each up to a concentration of 1 to 2 per cent. Mr. Skowronski's work indicated that silver and cadmium in small concentrations had very little effect upon the electrical conductivity.

Silver in concentrations of 0.025 to 0.075 per cent raises the recrystallization temperature of copper 100 C. Cadmium in amounts of 0.1 to 0.2 per cent is more effective by 20 to 50 C. Both elements add appreciably to the rupture properties of copper.

Tests made at General Electric Research Laboratory corroborate these statements. All specimens were reduced cold 26 per cent in cross-section. The stresses necessary to produce failure in 200 hr at 200 C were found to be:

Tough pitch copper	27 000 psi
Copper + 11.55 oz Ag per ton	32 000 psi
Copper + 26.6 oz Ag per ton	35 000 psi
Copper + 0.26 per cent cadmium	39 000 psi
Copper + 0.78 per cent cadmium	44 000 psi

Cadmium increases both the fatigue properties and the recrystallization temperature of copper, while silver in commercial percentages affects only the latter.

American Brass Co. data on tough pitch copper, drawn to a tensile strength of 48,000 psi and tested as a rotating beam to 300 × 10^6 cycles showed an endurance limit of 17,000 psi.

Bell Telephone Laboratory tests on tough pitch copper strip, rolled 6 numbers hard to a tensile strength of 52,600 psi and tested to 100 × 10^6 cycles, showed an endurance limit of 14,000 psi. Rotating beam tests, made at the American Brass Co. on soft cadmium copper containing 0.2 per cent cadmium and having a tensile strength of 37,400 psi, showed an endurance limit of 16,000 psi.

Bridgeport Brass Co. data on cadmium copper containing 0.9 per cent cadmium tested as a rotating beam showed an endurance limit of 29,000 psi as compared to 19,000 psi for tough pitch copper similarly treated.

Tests made at General Electric on a pneumatic fatigue machine on copper containing 0.9 per cent cadmium cold rolled 10 per cent showed an endurance limit of 20,000 psi at 100 × 10^6 cycles.

Railway Motor Commutators:

The birth of rupture testing, in the General Electric Co. at least, was occa-

sioned in 1935 by observations made on what then seemed to be unusual fractures in railway motor commutator segments. However, Clark and White at the University of Michigan had previously studied the rupture properties of steels. The fractures, observed during the manufacture of the commutators, extended from the bottom of the V section, common to all commutators, at an angle toward the bottom of the segment (Fig. 6). The fractures were intergranular (Fig. 7) with very little deformation and would today be immediately recognized as occurring over a period of time under stress at a temperature in excess of the recrystallization temperature (Fig. 8).

In the manufacturing process the copper segments were assembled on a steel core. A steel retaining ring was clamped in the V section around the periphery and the unit subjected to a 10-hr heating at 160 C, after which 120 tons total pressure was applied circumferentially through the steel retaining ring. A second step involved heating the commutator for 132 hr at 160 C during which the total circumferential pressure of 120 tons was maintained. Rupture occurred during the latter treatment.

Calculations indicated stresses at the bottom of the notch of 20,000 to 33,000 psi. Subsequent data obtained on the rupture properties of tough pitch copper indicated that rupture could be expected in such a stress range within the time of 132 hr.

The difficulty was completely eliminated by the use of copper containing 25 oz of silver per ton. So frequently shop troubles, such as this, coming to the attention of alert observers, must be regarded as opportunities and result in information which can be applied in diverse fields.

We might very properly pause at this point to consider the lesson offered by the commutator story.

1. It was our introduction to the time-temperature-stress type of failure.
2. It enabled us to explain many different failures in a variety of metals which we had seen before and since.
3. It was the impetus which started us on rupture testing.

The Copper Supply Situation and Cond-Al:

Copper as we all know is in short supply. The prospects of further curtailment in copper allotments and of an increasing supply of aluminum have prompted a search for areas where the latter may be substituted for the former. One such area was found to be large generator field coils. E.C. aluminum had on occasion been used for this purpose, but as the size and rotational speed of the generators increased, it became necessary to improve the physical charac-

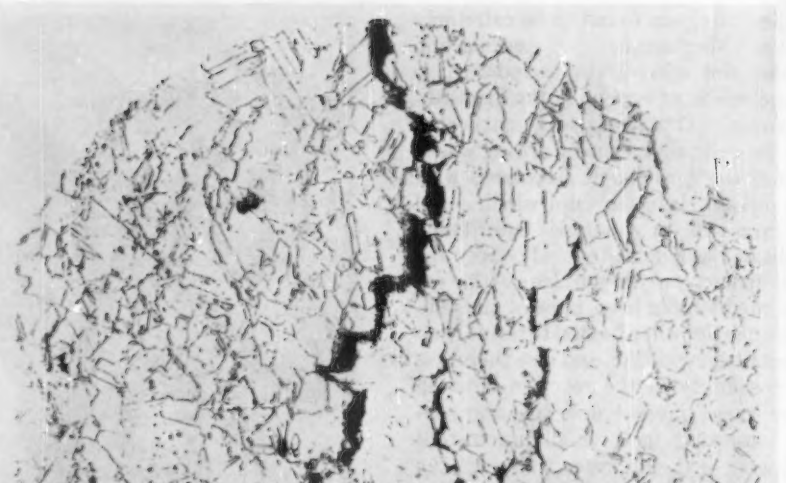

Fig. 7.—Commutator Failure Showing Intergranular Fracture (×100).

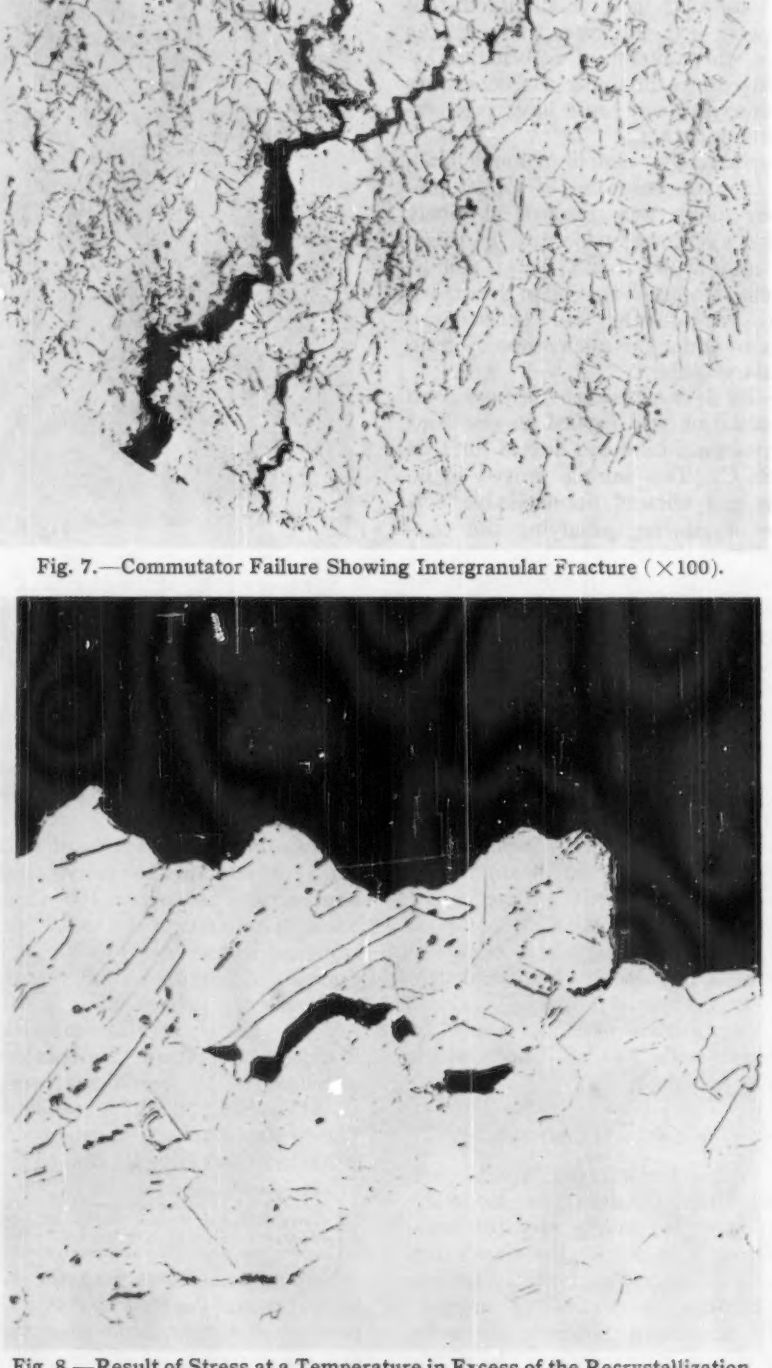

Fig. 8.—Result of Stress at a Temperature in Excess of the Recrystallization Temperature (×250).

teristics of aluminum again without seriously impairing its electrical conductivity.

Harrington's approach was quite similar to that used by Skowronski in the case of the copper alloys, and the result is an aluminum alloy of the magnesium-silicon type known to us as Cond-Al.

Cond-Al is an age-hardening alloy, the nominal composition of which is:

Iron	0.45 to 0.65
Magnesium	0.25 to 0.40
Silicon	0.08 to 0.15
Aluminum	Remainder

The heat treatment in use at present is: heat 4 hr at 560 C; cold roll 10 per cent; age 20 hr at 175 C.

A comparison of some of its physical characteristics is shown in Table I.

The important observation to be noted is that the deformation of Cond-Al in compression creep at stresses of 5000 to 10,000 psi is a minimum as compared to E. C. aluminum which cannot support these stresses. This improved creep resistance has been obtained with but a slight sacrifice in electrical conductivity.

It was in 1900 that Hadfield in England published his now historic paper in which he gave the results of tests on the properties of iron with silicon additions including magnetization and electrical resistivity to which he referred as "the most remarkable result we have yet obtained, the effect produced on the magnetic properties of iron by the addition of silicon."

In 1896 J. F. Kelley associated with Stanley at Pittsfield, Mass., had also found that the use of small quantities of silicon added to "soft" iron improved and stabilized the magnetic qualities.

Throughout the period extending from 1900 to the present, silicon steel for use in transformers has been steadily improved, largely through the efforts of Ruder and Morrill of the General Electric Co., Yensen of the Westinghouse Co., and Brown of Allegheny Ludlum Steel Co. (Fig. 9).

In 1936 the introduction of the first oriented crystal silicon steel strip reduced the loss to 0.35.

In 1941 modern types of oriented grain strip containing 3 per cent silicon dropped losses to 0.25.

Prior to 1903, low carbon steel was used in transformer cores and the loss in watts per pound at 10,000 B and 60 cycles was 1.72.

By 1905 with the introduction of the 3 per cent silicon steel the loss had dropped to 1.17.

From 1905 to 1933 the application of special rolling processes, control of grain size and increased silicon content to 5 per cent resulted in a further drop in loss to 0.55.

TABLE I.—SUMMARY OF TENSILE, PHYSICAL, AND COMPRESSION CREEP PROPERTIES OF HIGH CONDUCTIVITY COPPER AND ALUMINUM.

	Silver Bearing Copper 1/8 Hard	E. C. Aluminum Soft	Cond-Al
Stress for 0.1 per cent creep at 140 C in first 1000 hr, psi	17 000	2900	8000
Creep in first 1000 hr at 140 C at 5000 psi, mils per in.	Negligible[a]	Failed	0.3[a]
Creep in first 1000 hr at 140 C at 10 000 psi, mils per in.	Negligible[a]	Failed	2 to 3
0.2 per cent yield strength at 25 C, psi	23 000	5600	17 000
Tensile strength at 25 C, psi	33 000	11 700	20 000
Coefficient of expansion per deg Fahr	9.1×10^{-6}	13.1×10^{-6}	13.1×10^{-6}
Conductivity, per cent IACS	100	61	59

[a] Estimated from tests at higher stress.

I do not have the total savings in dollars which have accrued to the public as a result of the improvement in properties of silicon steel in transformers. Ruder has estimated that during the period 1920 to 1936 such savings amounted to $500,000,000 and, taking into consideration the increase in installed capacity from 35×10^6 kws in 1936 to 70×10^6 kws in 1950, I estimate the savings to date at between 1.5 and 2 billion dollars.

Permanent Magnets:

The improvement which has taken place in the permanent magnet steels is perhaps equally as striking as that described in the case of transformer sheets (Fig. 10).

Prior to the year 1885 carbon steel with 1 to 1.5 per cent carbon was used for such magnets. In that year the magnet steel with 5 per cent tungsten and

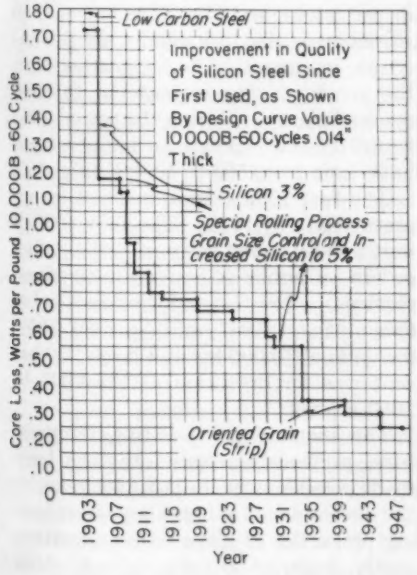

Fig. 9.—Transformer Sheet Steels.

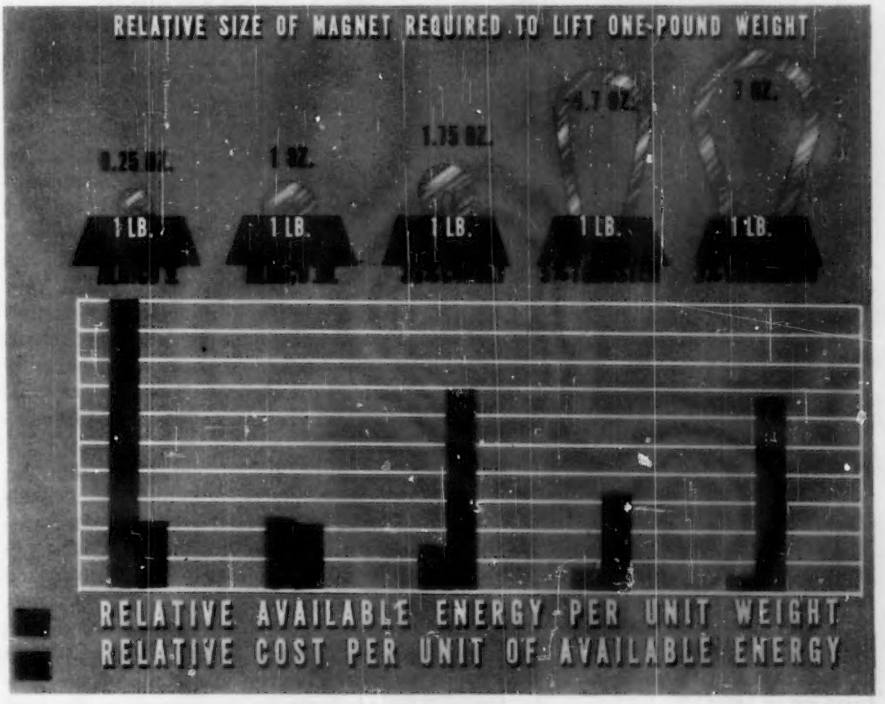

Fig. 10.—Permanent Magnet Materials.

0.8 to 1.0 per cent of carbon came into being.

In 1916, because of a tungsten shortage, permanent magnet steels were made to contain 3 per cent chromium with 0.8 to 1.0 per cent of carbon.

The following year saw the introduction in this country of Honda's magnet steel containing cobalt 36 per cent, tungsten 7 per cent, chromium 3.5 per cent, with a carbon content of 0.8 to 1.0 per cent.

In 1920 it developed that improved properties could be obtained by increasing the cobalt content to 42 per cent with small amounts of tungsten and chromium and carbon in amount of 0.8 to 1.0 per cent.

1934 witnessed the introduction as permanent magnets of the first precipitation-hardening nickel-aluminum-iron alloys made to contain 12 per cent nickel with 10 per cent aluminum now known as Alnico III.

In 1940 the composition cobalt 24 per cent, nickel 14 per cent, and aluminum 8 per cent, now known as Alnico 5 was standardized.

Recently a platinum-cobalt composition has shown a coercive force of high magnitude.

Insulation

The early designer of electrical equipment had at his disposal only materials of natural origin. With such materials he produced many remarkable designs of equally remarkable performance.

The better understanding of existing materials and the synthesis of resinous compounds have advanced the art and hence the design and performance of electrical machinery.

A modern 20-hp general-purpose motor and a 5-hp motor of the early 1900's are approximately equal in size and weight. The present-day motor has a much improved life and reduced maintenance. Part of this gain is due to the use of new insulating materials, principally replacement of space-consuming conductor insulation.

Motors used in domestic refrigerators have been reduced in size by over 50 per cent since 1930 due primarily to the use of synthetic resin conductor insulation, again with improved performance and reliability.

The varnish and enamels used in the early electrical machinery withstood a temperature of 75 C. The synthetic resin insulation (Formvar) may be used up to a temperature of 105 C. The fluorocarbon resins withstand temperatures up to 180 C.

The advantage of the higher temperatures in devices, such as air-borne equipment where weight is of paramount importance and in welding transformers where large currents for short periods of time are desired, is apparent.

From a metallurgist's point of view, it is interesting to observe that many of these solid electrical insulating materials have properties similar to metals. They have elasticity and malleability and when stressed they develop internal strains which can be relieved by heat annealing.

Formvar insulated coated wire, known as Formex, can be stretched until the wire breaks without losing its insulating coating. It is malleable to the extent that it can be rolled out to a flat ribbon without separation of the insulation from the metallic conductors. It can be wound cold on a mandrel whose diameter is equal to that of the wire, without cracking the insulation.

Another characteristic of some of the many insulating materials is that very many are partially microcrystalline, and this crystallinity depends on the thermal and mechanical treatment of the insulation. The materials which show crystallinity are Nylon, Teflon, F-1113, cellulose acetate, and cellulose ethers.

In addition to solid insulating materials, the electrical industry makes use of both liquids and gases. Transformers, for example, are insulated with petroleum oils and also with chlorinated organic liquids known as askarels. Nitrogen gas is used as an insulating material in cable construction. Gaseous sulfahexafluoride and some of the gaseous halogenated hydrocarbons are used as insulators in high-voltage apparatus.

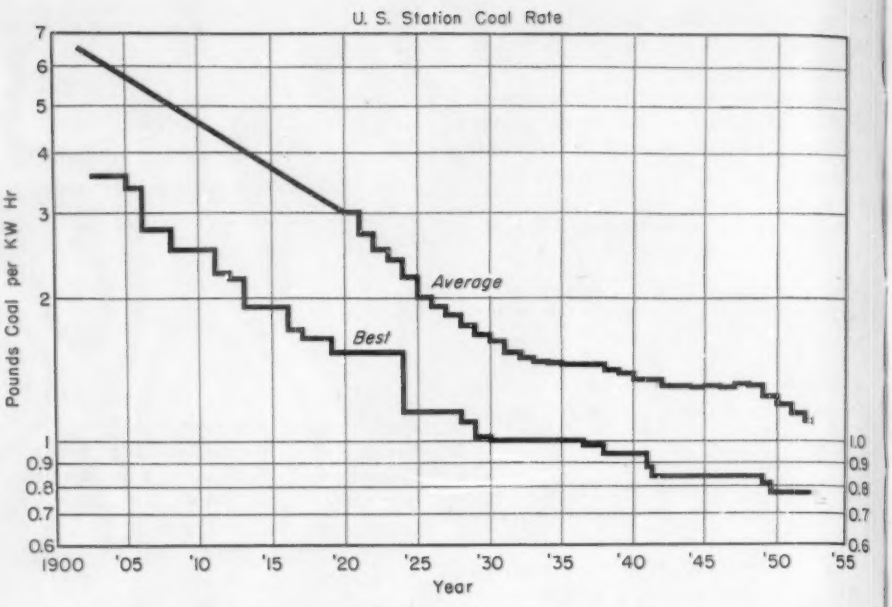

Fig. 11.—Increase in Generation Efficiency of Power Stations During Last Forty-five Years.

Many other similar examples could be cited and progress, in the way of new materials, new knowledge, new designs and processes, is being made rapidly in the whole field of dielectrics. Advances in the future should be commensurately greater than those of the past.

Temperature-Resisting Materials

The electrical industry is concerned with the generation of electric power (Fig. 11). During the last half century the efficiency of our public utility steam stations has increased from 6 lb of coal per kw-hr in 1902 to 1.14 lb per kw-hr in 1951. These are average figures. For the best stations, over the same period, the operating efficiency has increased from 3.6 lb per kw-hr in 1902 to 0.77 lb per kw-hr in 1951. The increase in efficiency is due principally to the increase in operating temperatures with the accompanying increase in thermal cycle efficiency. During the period 1905 to 1949 the operating temperatures have risen from 500 to 1050 F (Fig. 12).

The first 1050 F unit was put in operation late in 1948. The first 1000 F unit was activated early in 1946. Of all orders for public utility steam turbines, received by the General Electric Co. between May 1, 1947, and April 30, 1950, for units of 10,000 kw and larger, 50 per cent was for operation at the 1000 to 1050 F level.

The increase in operating temperature, previously referred to, has been made possible over the last fifty years by the development of new alloy steels having properties at elevated temperatures vastly superior to the carbon steels which were available in 1902. In cases

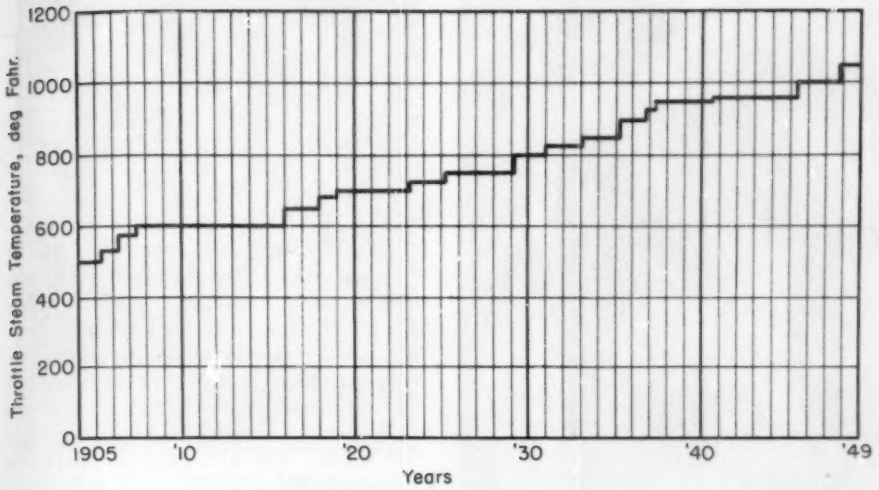

Fig. 12.—Increase in Steam-Turbine Operating Temperatures During Last Forty-five Years.

where austenitic steels have been used there is not only an increase in material cost but also in fabricating, and difficulties peculiar to the metallurgy of the austenitic steels may arise.

To determine the suitability of ferritic and austenitic steels at temperatures mentioned, a wide variety of tests is required. By comparing the properties of standard steels with those of new steels with improved properties, engineers added to their resources the new materials being steadily discovered, invented, and evaluated for useful application.

Creep and rupture tests performed at elevated temperatures, in addition to the usual tests normally performed at room temperature, have been of inestimable value in the selection of materials for high-temperature power generating equipment.

Ferritic Steels:

To illustrate the improvement in properties at elevated temperatures of the ferritic steels, five compositions have been chosen as shown in Fig. 13.

The spread in properties of these five steels increases markedly with rising temperature. At 75 F the proportional limit of the weakest and the strongest, for example between AISI 1015 and chromium - molybdenum - vanadium, varies by a factor of 2:1.

At 800 F the 1 per cent in 100,000 hr creep rate varies by a 5:1 factor and at 1000 F the 1 per cent in 10^5 hr creep rate varies by a factor of 13:1.

In each instance the 0.5 per cent molybdenum, the 1.0 molybdenum, and the molybdenum-vanadium compositions show properties intermediate in ascending order (Fig. 14).

The rupture strength of AISI 1015 and chromium-molybdenum-vanadium at 1000 F varies by a factor of 11:1, the other compositions, as in the case of the creep test, showing intermediate values.

Stability-Graphitization:

Perhaps one of the best examples of spontaneous cooperative research has been concerned with the stability of low-alloy steels in steam power generating systems.

In 1943 the now well-known failure of a high-temperature steam line occurred at the Springdale Station of the West Penn Power Co. The pipe, the composition of which was carbon, 0.5 molybdenum, had been in service $5\frac{1}{2}$ yr at a temperature of 935 F at a pressure of 1600 psi. The failure was attributed to the presence of chain or eyebrow graphite which had formed during operation in the heat-affected zone adjacent to a weld in the pipe (Fig. 15).

Since that time much work has been done, leading to the following conclusions:

1. The element most influential in promoting graphitization is aluminum, present not as Al_2O_3, but as acid-soluble aluminum.

2. A number of elements, of which chromium is the most potent, act as inhibitors of graphite formation.

3. Heat treatment before welding has an important influence on the tendency to graphitize. In general, a high-solution treatment followed by a rapid cool through the transformation range and high-temperature draw treatment

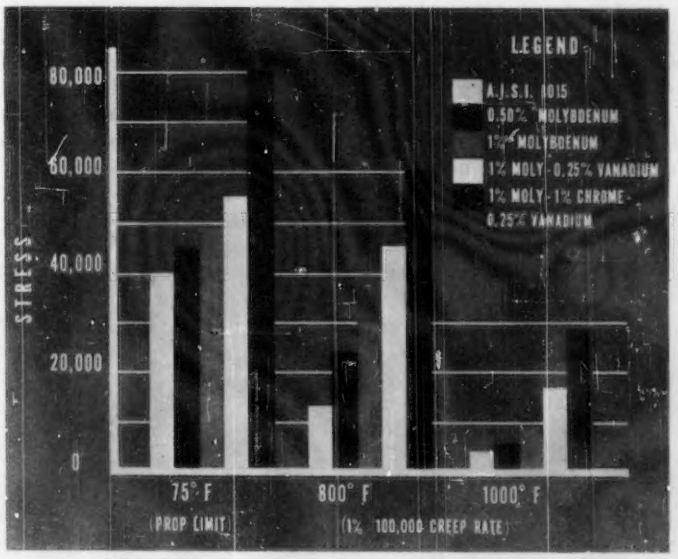

Fig. 13.—Elevated Temperature Properties of Ferritic Steels.

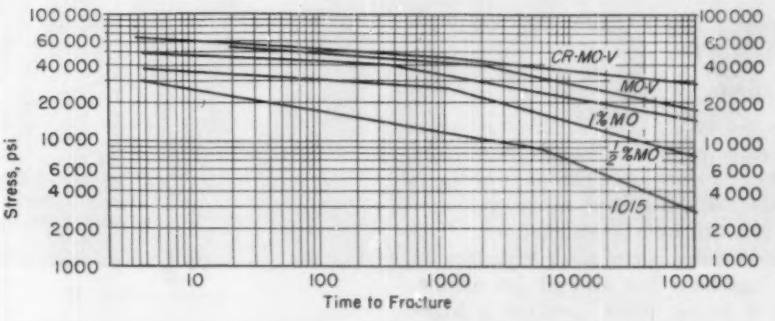

Fig. 14.—Rupture Strength at 1000 F.

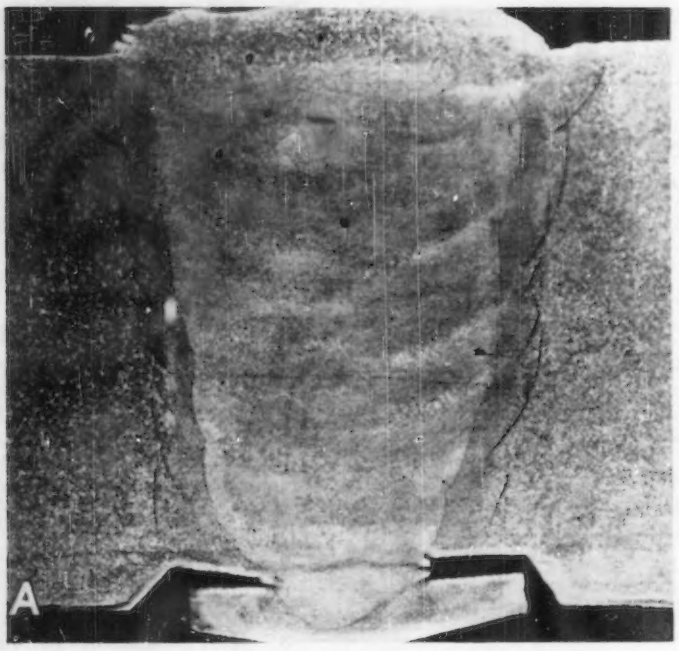

Fig. 15.—Chain or Eyebrow Graphite. (×6, reduced one half in reproduction.)

all tend to inhibit the formation of graphite.

High preheats during the welding operation, followed by high subcritical post weld treatments are plus factors in the suppression of graphite.

In 1950 the graphitization subgroup of the Metallurgy and Piping Subcommittee of the Edison Electric Institute published a summary of replies to a questionnaire composed of nine questions and submitted to the power industry. The published results of the questionnaire indicate a preponderance of opinion supporting the idea that normalizing or solution heat-treatment for rehabilitation helps in deferring rewelding of joints or replacement of pipe. A word of caution, however, suggests that the use of heat-treatment for the rehabilitation should be based on extensive tests on individual joints.

All of these statements now seem obvious to those skilled in the art. They were not obvious, however, in 1943. In about five years concentrated effort by the industry produced information which will make failures, like Springdale, on future installations extremely unlikely. This is truly a splendid accomplishment.

Gas Turbines:

No story dealing with the high-temperature properties of steels and other alloys would be complete without mention of those used in supercharger and gas turbine construction. The largest volume use of the gas turbine to date has been the aircraft jet engine. Such a power plant involves a high-temperature unit consisting of a rotating wheel or wheels with buckets on the periphery driven by hot gases and a compressor which furnishes large quantities of air for combustion.

Large numbers of superchargers were applied to the conventional aircraft engines during World War II. By far the larger number of wheels in these devices was made of Timken alloy and the buckets of a cobalt-chromium alloy.

Much investigational work has been and is being directed toward the development of alloys having superior high-temperature characteristics, including rupture (Fig. 16), creep, and fatigue properties and also alloys having lower strategic alloy content.

TABLE II.—STRESS-RUPTURE DATA.

Alloy	100 hr—1200 F	100 hr—1500 F
Timken	46 000	16 000
Cobalt-chromium alloy	52 000	19 000
Nimonic 80	58 000	14 000
S-816	68 000	23 000
M-252	80 000	26 000

The British jet engines make use of normalized and drawn ferritic bucket wheels and austenitic wheels and alloys of the Nimonic type for buckets.

In this country austenitic alloys are favored for wheels or wheel rims and either forged or cast cobalt base alloys for buckets. Stress-rupture properties of several typical austenitic alloys are shown in Table II.

Ultrasonic Testing

A test method that is playing an important role in assuring flaw-free material is ultrasonic inspection.

In the application of this versatile tool, ultrasonic testing has permitted examination of the internal condition of wrought parts with the same thoroughness that has been used for years in the X-raying of cast parts. Perhaps a few examples might illustrate the value of ultrasonic testing (Fig. 17) to the electrical industry.

Large turbine generator rotors (Fig. 18), weighing 75 to 80 tons, are routinely inspected by means of the ultrasonic test. The complete inspection takes about 2 hr, after which the forging is placed into one of three categories: (1) no ultrasonic indications; (2) some indications requiring flaw identification by other means; (3) numerous indications requiring several other correlating tests. It is of interest

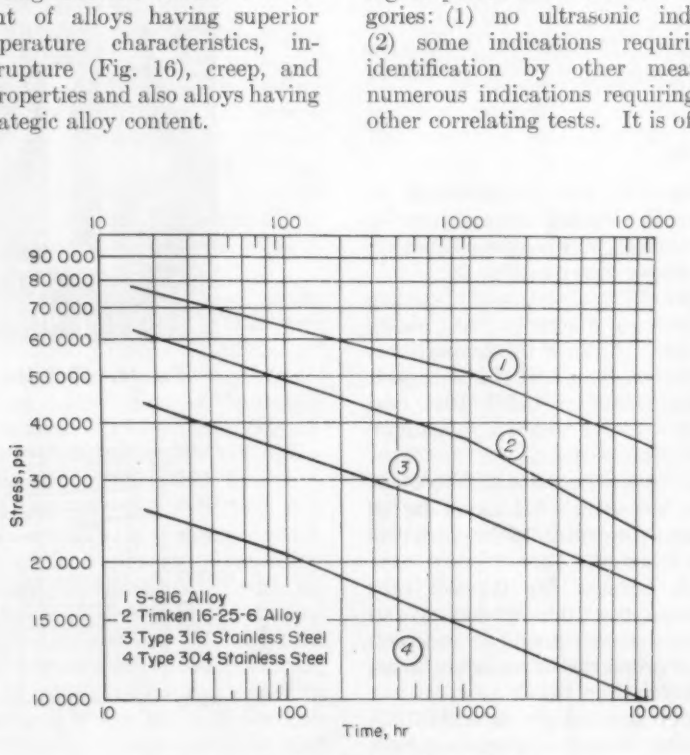

Fig. 16.—Rupture Strength at 1200 F.

Fig. 17.—Ultrasonic Testing.

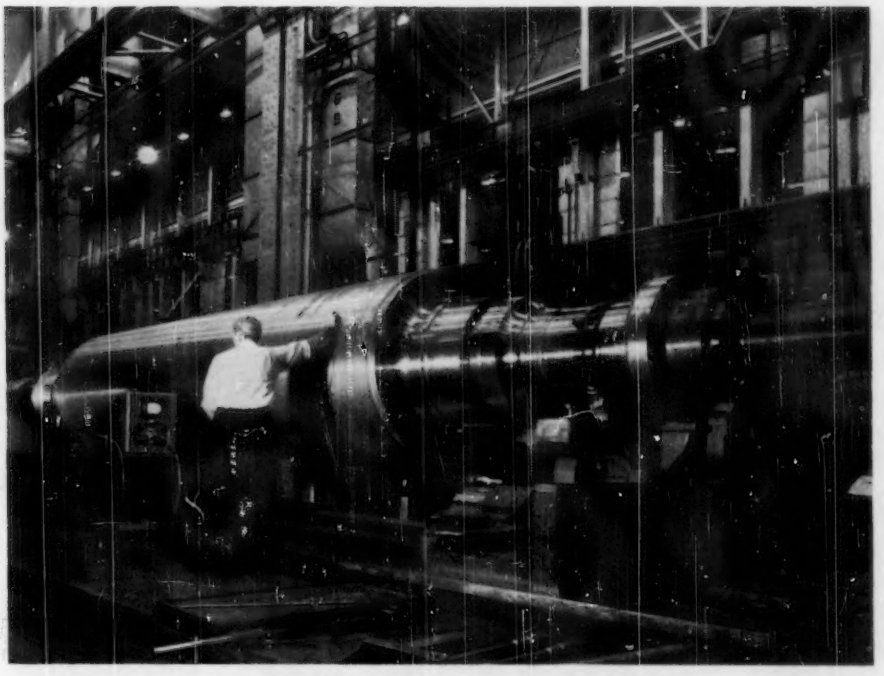

Fig. 18.—Turbine-Generator Rotor Inspection.

as well as encouraging to note that 85 per cent of the material falls in the first category, that is, no ultrasonic indications.

Retaining rings are the most highly stressed part of the turbine generator field assembly. Each generator has two rings, one mounted at each end of the rotating field and each carries a centrifugal load of the order of $1\frac{3}{4}$ million lb including that due to the ring itself. It is readily apparent that a small hidden flaw in this material could be disastrous. A mechanized ultrasonic test equipment automatically scans these rings, rejecting those showing discontinuities of appreciable magnitude.

The ultrasonic inspection of high-pressure steam piping was inaugurated as a result of a serious material failure. By means of this test longitudinal flaws have been detected in several lengths of pipe, thus preventing a repetition of the original failure. This particular ultrasonic application is quick and thorough and above all extremely reassuring. The test is such that it may be performed on installed piping, if desired.

These examples are a few of the ways ultrasonic testing has been put to work to weed out defective material before it gets into service. Most ultrasonic testing is done before or during the early stages of machining, thus accomplishing the added result of preventing large manufacturing losses on faulty material.

(a) 3080-hr operation. (b) 3832-hr operation. (c) 4804-hr operation.

Fig. 19.—Corrosion of Wall Tubes in Mercury Boiler.

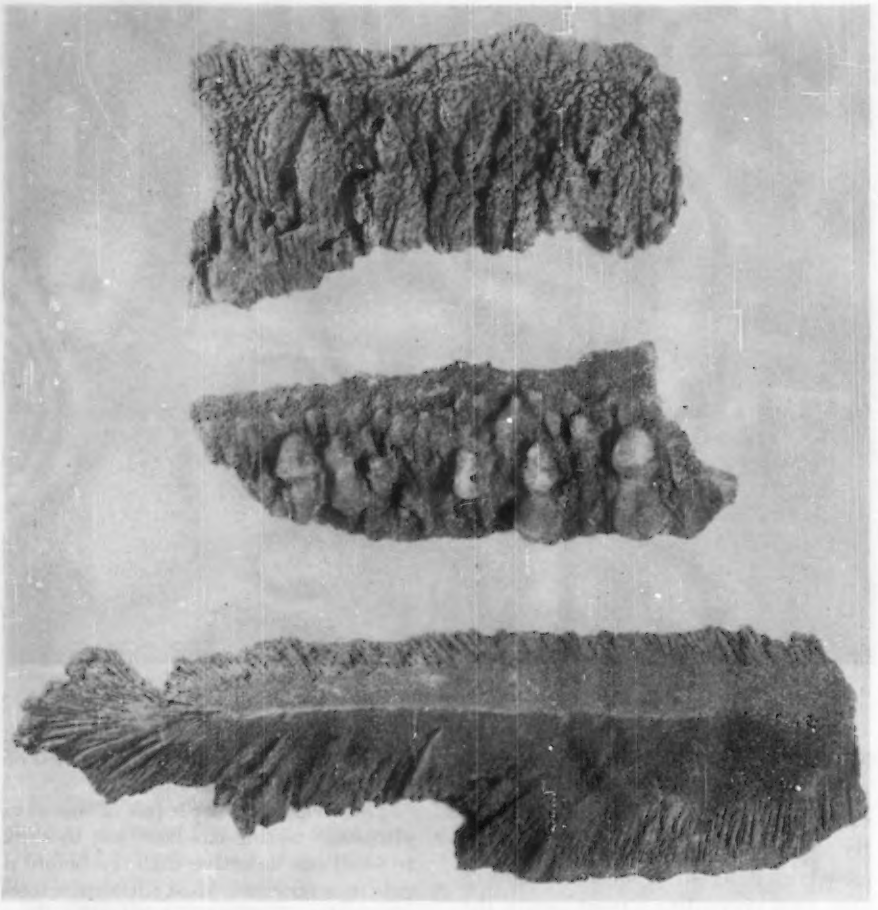

Fig. 20.—Ash Specimens from Mercury Boiler (×1).

Oil Ash Corrosion

Some twenty years ago, with the advent of the first oil-fired mercury boiler unit, it was observed that ash from residual fuel oils, particularly those containing vanadium, is highly corrosive at 1250 F to iron and iron containing small amounts of chromium. Since that time the gas turbine using residual fuel oil has come into use and the same problem has appeared again in connection with highly alloyed materials. In addition, with the increase in operating temperatures of the steam turbine to 1050 and 1100 F, consideration must be given to steam boilers. Consequently many investigators have focused attention on the problem and among them is C. T. Evans, Jr., who received the Society's 1951 Sam Tour Award for his paper "Oil Ash Corrosion of Materials at Elevated Temperatures."[2]

The results of the early investigations of the oil ash problem led to a rather simple explanation of the phenomenon. The attack invariably appeared to have been associated with a liquid phase. Vanadium pentoxide melts at 1274 F. It was assumed that the melting point of the pentoxide was reduced by the presence of the sodium compounds in the ash to a point resulting in a liquid phase which caused the trouble.

Subsequent work, however, has indicated that the explanation of the vanadium attack is not as simple as at first supposed.

Canneri[3] has shown that V_2O_5 in equilibrium with $NaVO_3$ (sodium metavanadate) melts at 1040 F.

L. H. Satz, of our laboratory, has continued the study of vanadium oxide attack and has made many interesting observations.

After operating four months the surface of the vertical wall tubes in the flame zone of a mercury boiler was found to have been subjected concurrently to a "worm track" and "pitting" attack (Fig. 19(*a*)).

After an additional month of operation the most noticeable change was an increase in pitting and a decrease in the sharpness of the worm track edge, the implication being that "worm track" attack occurs at the outset, then decreases in rate, but that the pitting attack continues (Fig. 19(*b*)).

During the ensuing six weeks, the "worm track" areas were nearly obliterated but the "pitting" continued (Fig. 19(*c*)).

Three specimens of ash taken at different times from the surface of the fog bank tubes suggest (Fig. 20):

(*a*) The deposition of the ash in the form of "mountain rime" type of structure from the gas stream, with the crystallites growing into the direction of the stream.

(*b*) The fusion of the surface of the ash deposits into nodules.

(*c*) The liquefying and flowing away *with* the gas stream of the surface of the ash deposit.

These deposits do not represent the flame zone deposit where the most intense corrosion occurs.

An examination under polarized light at a magnification of 100 × of a flame zone deposit associated with the intense corrosion reveals its crystalline nature and suggests its formation by sublimation (Fig. 21). The deposit is heterogeneous. The white area showed a refractive index and solubility corresponding to Na_2SO_4.

The analysis of this particular sample of ash is:

SiO_2, per cent	5.80
Fe_2O_3, per cent	32.20
Cr_2O_3, per cent	2.28
V_2O_5, per cent	16.06
Al_2O_3, per cent	3.42
NiO, per cent	6.72
SO_3, per cent	21.14
Na_2SO_4, per cent	37.49

Contrary to our original ideas on the subject, observations now indicate there is no general fluidity of the ash sufficient to cause "washing away" of the protective seal. However, examination of the photomicrographs does indicate that a liquid phase is involved but in the form of a film rather than a large liquid mass.

A suggested mechanism of attack by fluid films is indicated by the two photomicrographs at 100 ×, shown in Fig. 22, one with normal illumination, as shown at the left, and the other on the right with polarized light. The areas photographed are from the bottom of a pit in a boiler tube section removed after 17 months of service with the ash deposit intact on the surface.

Under normal illumination the ash appears black, the oxide scale appears gray. Two layers of scale of a porous and fissured structure can be seen.

Under polarized light the ash appears gray and the two thin layers of ash are visible. The important observation is that there is a thin layer of ash, solidified from a liquid adjacent to the metal surface. This, of course, means that in spite of all the self protection inherent in the 5 per cent chrome alloy tube the

[2] C. T. Evans, Jr., "Oil Ash Corrosion of Materials at Elevated Temperatures," Symposium in Corrosion of Materials at Elevated Temperatures, Am. Soc. Testing Mats. (1950). (Issued as separate publication, *STP No. 108.*)

[3] G. Canneri, "Sui Vanadicovanadite," *Gazetta Chimica Italiana*, pp. 6–25 (1928).

Fig. 21.—Flame Zone Deposit.

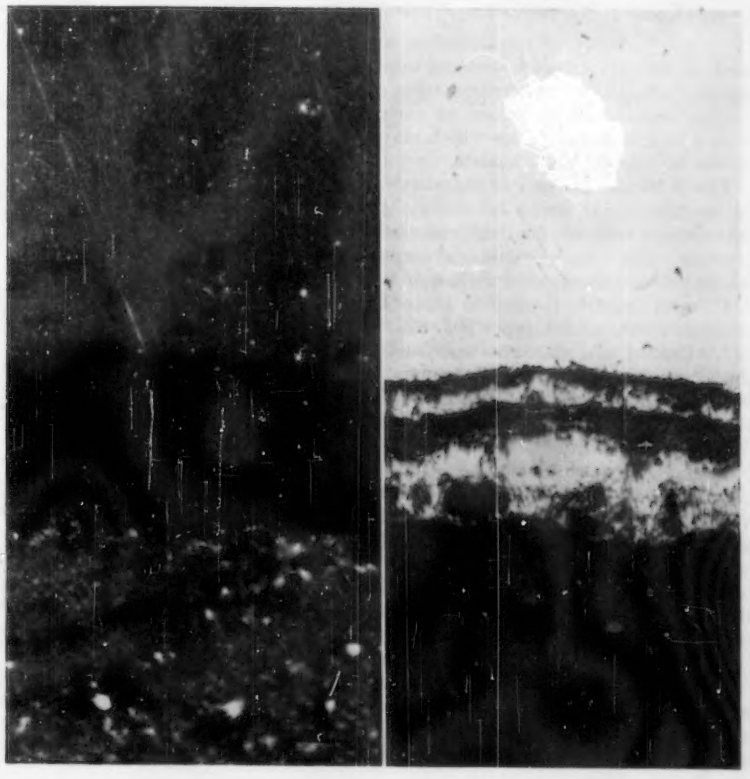

Fig. 22.—Corrosion Attack by Fluid Ash Films.

Fig. 23.—Protective Oxide (Fissured) (×100).

Fig. 24.—Intergranular Sulfide Penetration (×100).

ash has found its way to the fresh metal surface.

A further illustration of the fissured nature of the protective oxide, which fissures constitute the probable avenues of approach of the liquid ash film, is shown in Fig. 23.

That this corrosion mechanism is not a simple accelerated oxidation problem is illustrated in Fig. 24.

Here is seen intergranular sulfide penetration which is believed to be associated with the worm track phenomenon. Evidences of sulfides and worm tracks occur in the same areas on side of the tubes near the tangent point. The sulfide attack we believe to be more intense at the beginning than the pitting which we believe to be associated with vanadium compounds.

The practical solution of this very troublesome problem is unknown. It is believed that if an additive can be found which will raise the melting point of the liquid constituent of the ash to a point where it will remain solid that most of the trouble will be history.

Evans found that calcium oxide gives promise of being of substantial help.

Evidence indicates that aluminum oxide may also be helpful.

Ceramic Coatings Prevent Carbon Absorption

Some of the stainless steels used in aircraft exhaust systems tend to absorb carbon under severe operating conditions, causing precipitation of carbides at or near grain boundaries which may result in failures of exhaust parts.

The National Bureau of Standards has demonstrated in recent laboratory tests that certain ceramic coatings successfully prevent this undesirable absorption. Several were investigated including types A-417 and A-19H, applied to three 18–8 stainless steels: AISI types 304, 321, and 347. Coated and uncoated specimens of the alloys were subjected to strongly carburizing conditions at 1350, 1500, and 1650 F.

In the recent study, sponsored by the National Advisory Committee for Aeronautics, small sheets of the various coated and uncoated alloys were packed in an alloy box with a commercial carburizing compound. The box was then placed in a furnace and slowly heated to one of the three selected temperatures. After 4 hr at this temperature, the box was removed from the furnace and allowed to cool in air.

Specimens thus treated were examined metallographically. In no case did the metal become exposed in coated specimens. Most of the uncoated specimens gave evidence of carbon absorption to depths as great as 0.007 in., but in most cases the ceramic coatings completely prevented absorption.

Of those studied, NBS ceramic coating A-19H proved most effective in preventing carbon absorption under all test conditions. However, the extreme severity of the test carburizing conditions would probably never be encountered in the practical operation of aircraft exhaust systems, and any of several coatings might well prove fully satisfactory in service.

Chromium and Glass High-Temperature Coatings for Molybdenum

Because of its high melting point (4750 F) molybdenum offers possibilities for use in jet aircraft engines, but if used at jet engine temperatures, it must be protected from rapid oxidation.

The National Bureau of Standards, under sponsorship of the National Advisory Committee for Aeronautics, has recently conducted a study of protective coatings for molybdenum composed of chromium and frit (glass). Results indicate that such coatings greatly extend the useful life of molybdenum at high temperatures, giving better protection than either chromium or ceramic coatings alone. Various chromium-frit coatings were bonded to molybdenum specimens, then subjected to oxidation tests under tension in the range 1500 to 1800 F and to flame tests in the range 2000 to 3000 F. At temperatures of 1500 to 1800 F the coated specimens lasted for 1000 to 3000 hr. At 2800 F with no applied load, protection for as much as 7 hr was attained, enough to be valuable for some applications.

Molybdenum specimens were first coated with one of several powdered chromium-bearing base coats, which in some cases also contained some frit (glass). After firing of the base coat, in either a hydrogen or argon atmosphere, a ceramic seal-coat containing no chromium was applied to some of the specimens. Test results indicate that the most durable coatings resulted from application of a glass-free chromium base coat, followed by a glass seal coat. Addition of a third coat, consisting of lower melting glass, resulted in a coating showing the highest durability of all those investigated.

BOOK REVIEWS. . .

Plastics Molding

THE enormous growth of the plastics industry during and since World War II has made it impossible to cover in one publication all its many phases. This volume concentrates on one important aspect of the now huge industry—molding—its equipment, principles, and the accessories that permit the molder to attain a high degree of versatility.

The author, John Delmonte, who is a consultant to the Plastics Institute and President of Furane Plastics Inc., is a member of ASTM, active in Committee D-20 on Plastics, and in the Southern California District.

As he states in the Preface, Mr. Delmonte has endeavored to "glean the basic principles of molding from the many supporting activities and at the same time, to present useful design criteria which should eliminate the guesswork unfortunately pervading many molding operations."

The approach is from the engineering standpoint and the author has prepared his material in a manner designed to be of use not only to the plastics engineer but to the plant superintendent as well.

In the organization of the subject matter, flow of materials is considered first, and then the techniques for handling the materials once the flow has been established. Maximum emphasis has been placed on the selection and adaptation of equipment to molding problems. The important considerations of heat and pressure generation, distribution, and application, instrumentation, and plant layout which are all too frequently relegated to a background position, receive well-deserved attention in chapters on pumps, accumulators, valving, and heating.

This 500-page book is copiously illustrated with pictures, graphs, and drawings. The publishers are John Wiley and Sons, Inc., New York City, and copies are priced at $9.

Practical Radiography for Industry

THIS volume is written for those who are now or who will be engaged in planning and using radiographic inspection in the manufacturing industries. As such it provides radiographers, inspectors, metallurgists, and engineers with concrete working information on modern radiographic techniques.

The author, H. R. Clauser, who is a member of ASTM and active on Committees E-7 on Non-Destructive Testing and B-9 on Metal Powders and Metal Powder Products is associate editor of *Materials and Methods* and has a background of extensive industrial experience in the field.

With the aid of nearly 200 illustrations including sample radiographs showing actual defects in metals parts, Mr. Clauser provides detailed information on set-up procedures, exposure factors and techniques, radiograph quality, films and film processing, and screens and filters. Comprehensive coverage is given the interpretation of radiographs of castings and weldments; including the identification of defects or discontinuities in various materials, and discussions of the applicable standards. Separate chapters deal with gamma-ray radiography, fluoroscopy, high-voltage radiography, and miscellaneous applications which include microradiography, thickness gaging, and high-speed radiography, and give the latest information on 1, 2, 10, and 22-million volt X-ray equipment.

While the author had endeavored to cover adequately the most important and useful aspects of the subject, the book is not intended as an exhaustive review, and the material is treated in a concise and relatively nontechnical manner that can be comprehended by those with little or no training in physics and mathematics.

Priced at $7.50, this 300-page book is published by Reinhold Publishing Corp., 330 W. 42 St., New York, N. Y.

Quality Control and Industrial Statistics

THIS book, intended primarily as an upperclass engineering and business test, is also designed by the author, Acheson J. Duncan, to serve as a reference volume for quality control engineers and industrial research personnel.

The first section deals with the fundamentals of probability, frequency distributions, and sampling. Application of these basic tools in sampling inspection is dealt with in Parts II and III, "Acceptance Sampling by Attributes" and "Acceptance Sampling by Variables." Control charts are discussed in Part IV; Part V covers that area of statistical theory that is especially pertinent to industrial research, including the estimation of lot and process characteristics, the theory of testing hypotheses, tests of differences, analysis of variance, regression, and design of experiments.

This 660-page text is well indexed, amply referenced, and contains a great deal of illustrative material. The publisher is Richard D. Irwin, Inc., Chicago, Ill.

Bibliographic Survey of Corrosion

THE National Association of Corrosion Engineers has recently announced the availability of "Bibliographic Survey of Corrosion 1946–1947." This survey is similar to that published in 1948 prepared by Robert D. Misch, James T. Waber, and Hugh J. McDonald, entitled "Bibliographic Survey of Corrosion 1945." Both of these publications are intended to be "practical guides to corrosion literature." Following the NACE Abstract Filing System Index, the abstracts are divided into eight main groups which are further classified under varying numbers of subgroups. The main groupings are (1) General, (2) Testing, (3) Corrosion Types and Influencing Factors, (4) Corrosion Environments, (5) Preventive Measures, (6) Materials of Construction, (7) Equipment, and (8) Industries.

Each abstract is listed with a triple number, the first part of which is the group division number, the second is the subgroup number, and the third is its number within that subgroup. As a help to users of these surveys, an appendix has been added as an aid in locating unfamiliar foreign or domestic journals. Part 1 of the appendix indicates how journals may be located and Part 2 indicates services which do copying work. The 1946–1947 survey, numbering almost 300 pages and containing more than 2500 abstracts, is available from the National Association of Corrosion Engineers, 1061 M & M Building, Houston 2, Tex., at a cost of $7 to NACE members and $9 to nonmembers. The 1945 survey is available from the same source at a cost of $4 to NACE members and $5 to nonmembers.

Reviews of Petroleum Technology

JUST published is Volume 12 of the Institute of Petroleum's "Reviews of Petroleum Technology." This volume covers in general the year 1950 and practically all phases of the petroleum industry are dealt with, there being over 3300 references to articles which appeared in the literature during the period under review.

Also included in this book are a few reviews covering the period 1949–50 on general geology and development, engine testing (fuels and lubricants) furnace fuel oil, lubricants, and engines and automotive equipment.

The 513 pages of this book which include subject and author indexes, contain a wealth of summarized information in readily available form. Copies can be obtained from the Institute, 26 Portland Place, London W. 1, the price being £2.10 post free.

Research and Development in the USAF

HEADQUARTERS has received an advance copy of a booklet prepared by the Air Force to acquaint industry with the new Air Force Research and Development Organization.

The stated purpose of this publication is "to explain briefly the organization of ARDC and to outline for present and potential contractors the procedures to be followed in establishing contact with the Air Force concerning participation in the research and development program."

To accomplish this objective the booklet describes briefly the twin phases of research and development work and the various centers where the work is carried on, listing for each center its type of research or application and the material and equipment employed.

Interested organizations can obtain copies of the booklet by writing to the Commanding General, Headquarters, Air Research and Development Command, P.O. Box 1395, Baltimore, Md. Attention: Director of Procurement, Contractors' Relations Office.

PROFESSIONAL CARDS

On this page are announcements by leading organizations and individuals of their services.

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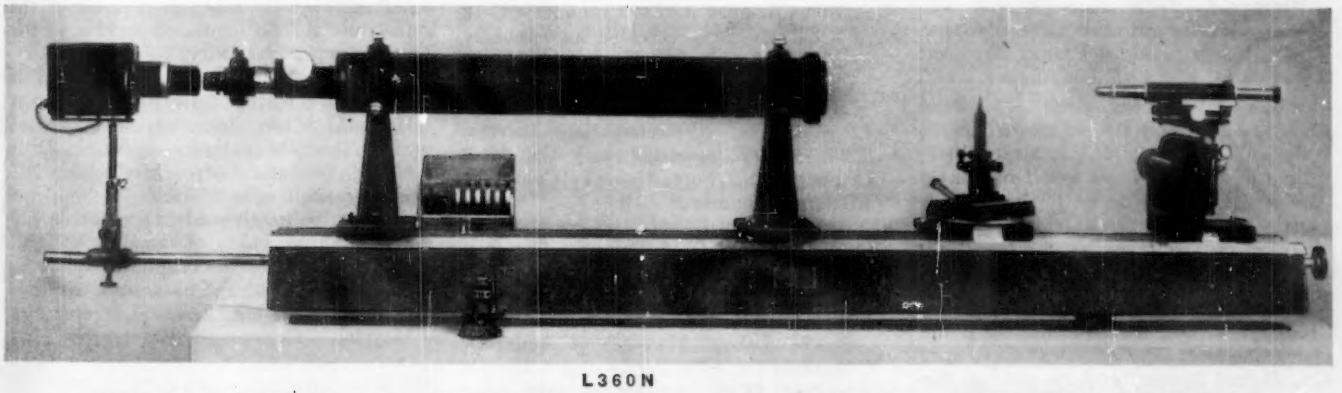

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PERSONALS...

News items concerning the activities of our members will be welcomed for inclusion in this column.

NOTE—These "Personals" are arranged in order of alphabetical sequence of the names. Frequently two or more members may be referred to in the same note, in which case the first one named is used as a key letter. It is believed that this arrangement will facilitate reference to the news about members.

At the annual meeting of the American Welding Society held in Philadelphia this month **Fred L. Plummer,** Director of Engineering, Hammond Iron Works, Warren, Pa., was elected President; **Eric R. Seabloom,** Supervisor of Field Engineering, Crane Co., Chicago, was elected First Vice-President; and **J. H. Humberstone,** Vice-President of Air Reduction Co., Inc., New York City, was named Second Vice-President. All three are active in ASTM technical committee work.

At the recent annual meeting of the Society for Non-Destructive Testing, the following men, all active in ASTM Committee E-7 on Non-Destructive Testing, were elected to office: **Robert C. McMaster,** ASTM's 1952 Marburg Lecturer, of Battelle Memorial Institute, was named President; **Philip D. Johnson,** of Evanston, Ill., was re-elected Secretary; and **Gerold H. Tenney,** of Los Alamos Scientific Laboratory, was named Treasurer.

Norman L. Bailiff, formerly with The Marley Co., Inc., Kansas City, Mo., has accepted a position as Project Engineer with Fluor Corp., Ltd., Los Angeles, Calif.

Milton F. Beecher, head of Norton Co.'s Research and Development Laboratories (Worcester, Mass.) since 1941, retired as Vice-President and Director on August 31.

George T. Boli, President, Northern Malleable Iron Co., St. Paul, Minn., was elected Vice-President of the Malleable Founders' Society.

George L. Buc, until recently with the Calco Chemical Div., American Cyanamid Co., Bound Brook, N. J., is now on the technical staff of the Tidewater Associated Oil Co., Bayonne, N. J.

William Robert Deitz has accepted a position as Supervisor of Laboratory, National Petro Chemical Corp., Tuscola, Ill. He was formerly associated with The Neville Co., Pittsburgh, Pa., as Manager of Laboratory Services.

Howard P. Ferguson, for many years Chief, Refining Control Div., Standard Oil Co. (Ohio), Cleveland, has been appointed Manager of the company's No. 2 Refinery and the Lithograph Can Factory. Mr. Ferguson has participated in and contributed to the growth and development of Sohio's refining control organization for the past 20 years. An important contributor to ASTM technical and district activities, he was the recipient of an ASTM Award of Merit in 1950 for notable accomplishments in promoting the work of the Society.

Henry S. Freynik has been elected Vice-President of the Riverside Metal Co., Riverside, N. J. Associated with the company since 1923 he had been Chief Metallurgist for the past 12 years. Mr. Freynik is active both in this country and Europe in the non-ferrous metals field. In ASTM he has served on Committee B-5 on Copper and Copper Alloys for a number of years, and is currently a member of the Philadelphia District Council.

Leo A. Goldblatt, formerly with the Naval Stores Research Div., U. S. Dept. of Agriculture, Olustee, Fla., now heads the Oil Chemistry Section, Oil Seed Div., Southern Regional Research Laboratory of the Department in New Orleans, La.

Arthur Halpern, until recently with the Burndy Engineering Co., Inc., Norwalk, Conn., is now on the staff of the Pasadena Research Labs., Pasadena, Calif.

Wesley W. Horner, of Horner & Shifrin, Consulting Engineers, St. Louis, Mo., and Chairman of ASTM Committee C-13 on Concrete Pipe, received an honorary Doctor of Engineering degree from Washington University.

Harold E. Hosticka, formerly with the U. S. Bureau of Reclamation, Denver, Colo., is now associated with the Ideal Cement Co., Fort Collins, Colo., as Research Engineer.

Theodore J. Kauer has been named Chief Engineer, Ohio Turnpike Commission, Columbus. He previously had served as Director of the Ohio Highway Dept.

R. W. Lahey, Manager of American Cyanamid Co.'s Packaging and Materials Handling Dept., retired recently after service with the company since 1929. Mr. Lahey has held membership for many years on several committees of both the Manufacturing Chemists Assn. and ASTM.

Robert C. Madden is now Laboratory Metallurgist, Columbia-Geneva Steel Div., U. S. Steel Corp., Provo, Utah. He was previously associated with the Kaiser Steel Corp., Fontana, Calif.

Dave Ian Marlow, formerly with Wyandotte Chemicals Corp., Wyandotte, Mich., has accepted a position as Test Equipment Design Engineer, North American Aviation, Inc., Downey, Calif.

E. C. Medcalf has been named head of the Coal Tar Chemicals Dept., Calco Chemical Div., American Cyanamid Co., Bound Brook, N. J., succeeding the late Q. T. Dickinson. Mr. Medcalf joined the Division in 1933.

Kenneth H. O'Brien, formerly with the Porter-Urquhart Assn., Newark, N. J., is now on the technical staff of O. J. Porter & Co., Los Angeles, Calif.

Harry W. Pierce has been elected to the post of Executive Vice-President and Director of the New York Shipbuilding Corp., Camden, N. J. Affiliated with the corporation since 1930, he has been assigned responsibility for operations of the company shipyard following the resignation of Thomas H. Bossert as president.

Elmer R. Queer, Professor of Engineering Research and Assistant Director of the Engineering Experiment Station at Pennsylvania State College, has been named head of the Engineering Research Department. Professor Queer is Chairman of ASTM Committee C-16 on Thermal Insulating Materials.

Carey F. Ramey, for many years Chief Chemist of the Standard Oil Co. of California, and latterly Assistant Manager of the Products Acceptance Dept. of the same company, which department provides a liaison between manufacturing, research, and marketing, retired as of September 1, and has taken up new duties as Vice-President of Faber Laboratories of New York, Inc.

Ansel T. Rogers, formerly with the Lehigh Materials Co., West Orange, N. J., is now Manager, Ready-Mix Concrete Dept., Ewell Engineering & Contracting Co., Lakeland, Fla.

Bernard E. Schaar, President, Schaar and Co., Chicago, is the 1952 recipient of the Honor Scroll of the American Institute of Chemists, this award being made annually by the Chicago chapter of the Institute for distinguished service to the profession of chemistry.

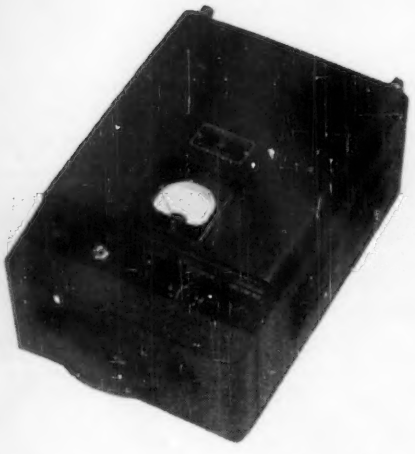
Julius C. Scharmer, until recently with the Borg-Warner Corp., Muskegon Heights, Mich., has become identified with the Deepfreeze Appliance Div., Motor Products Corp., Mundelein, Ill., as Products Engineer.

Erwin Sohn, formerly Director of Research, Eljer Co., Enamelware Div., Salem, Ohio, is now Consultant, Research Dept., Eagle-Picher Co., Joplin, Mo.

S. S. Steinberg, Dean, University of Maryland College of Engineering, has been awarded, by order of President Truman, a special certificate of merit for his work as Chairman of the Committee on Education of the President's Conference on Industrial Safety.

Thomas G. Stitt, Chief Inspecting Engineer, Pittsburgh Steel Co., Allenport, Pa., who received an ASTM Award of Merit in 1950, in recognition of outstanding service in Committee A-1 on Steel, has been selected also by the General Committee of the American Petroleum Institute, Dallas, Tex., to be one of the recipients for 1952 of the Institute's Certificate of Appreciation, presentation to be made at the API meeting in November in Chicago. The award is in appreciation and recognition of the constructive service that Mr. Stitt has rendered in the work of the Institute's Division of Production.

(*Continued on page 68*)



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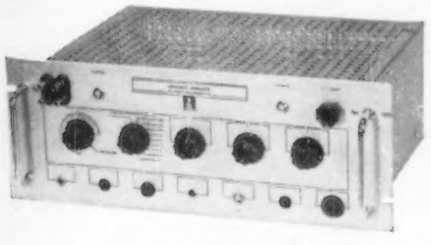

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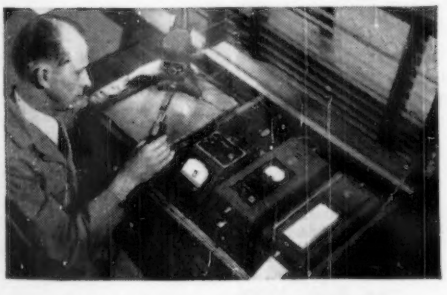

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(*Continued from page 66*)

Ernest G. Tomlinson, Designer, is now associated with United Engineers & Constructors, Philadelphia, Pa.

Peyton Wheeler has joined the Research Dept. of Edgar Brothers Co., McIntyre, Ga. He was formerly with the Southern Research Institute, Birmingham, Ala., where as head of the protective finishes research programs for the past four years he supervised important studies and developments. In his new capacity he will concentrate on the research and development of ASP pigments as inerts in protective coatings.

Merritt A. Williamson has been named Director of Research, Burroughs Adding Machine Co., Philadelphia, Pa. He was previously with the Pullman Standard Car Mfg. Co., Chicago, Ill.

A. G. Wyler, City Engineer, New Orleans, La., was elected Treasurer of the American Public Works Assn. at its recent annual meeting in Los Angeles, Calif.

The Society Appoints...

Announcement is made of the following appointments of Society representatives

The following appointments have been made to Award Committees:

Dudley Medal Committee—R. E. PETERSON, Westinghouse Electric Corp.; WALTER RAMBERG, National Bureau of Standards; and W. R. MYERS, E. I. du Pont de Nemours & Co., to serve with C. E. PROUDLEY, North Carolina State Highway and Public Works Commission; R. C. PLATOW, U. S. Plywood Corp.; and DAVID WOLOCHOW, National Research Council (Canada), with Mr. Proudley serving as chairman.

Richard L. Templin Award Committee—SAM TOUR, Sam Tour & Co., to serve with T. SMITH TAYLOR, U. S. Testing Co., Inc., and W. A. REICH, General Electric Co., with Mr. Taylor serving as chairman.

Sam Tour Award Committee—A. P. JAHN, Bell Telephone Laboratories, Inc., to serve with R. B. MEARS, United States Steel Co., and H. A. PRAY, Battelle Memorial Institute, with Mr. Mears serving as chairman.

Erratum

WE REGRET that in the review of Walter H. Kohl's book, "Materials Technology for Electron Tubes," which appeared in the July BULLETIN, the author's name was misspelled.

Mr. Kohl, who was formerly connected with Collins Radio Co., Cedar Rapids, Iowa, is now a Research Associate in the Electronics Laboratory at Stanford University.

NEW MEMBERS···

The following 45 members were elected from August 21, to September 25, 1952, making the total membership 7262... Welcome to ASTM

Note—Names are arranged alphabetically—company members first then individuals.

Chicago District

BORG EQUIPMENT DIVISION, THE GEORGE W BORG CORP., D. T. Van Alen, Chief Engineer, 120 S. Main St., Janesville, Wis.

LABLINE, INC., Alexander [illegible]owman, President, 217 N. Desplaines St., Chicago 6, Ill.

EDE, RICHARD H., Process Metallurgist, United States Steel Co., 208 S. LaSalle St., Chicago 90, Ill.

HERBST, HENRY W., President, Biwax Corp., 3445 Howard St., Skokie, Ill.

HILLER, MELVIN C., Material Research Engineer, Hamilton Manufacturing Co., Two Rivers, Wis.

Cleveland District

WILLIAMS, DONALD C., Chief Metallurgist, Addressograph Multigraph Corp., 1200 Babbitt Rd., Cleveland 17, Ohio.

Detroit District

WALTER, C. N., Purchasing Agent, The Austin Co., Cleveland, Ohio. For mail: Box 431, Kalamazoo, Mich.

New England District

AMERICAN TWINE AND FABRIC CORP., Thomas Nelson, Managing Director, Box 330, Portsmouth, N. H.

FENN, RAYMOND T., Chief Engineer, Sterling Engineering Corp., Box 559, Winsted, Conn.

ROSENSTEIN, S. N., Purchasing Agent and Secretary, The Electric Motive Manufacturing Co., Willimantic, Conn.

New York District

CAMCO PRODUCTS, James P. Novaro, Partner, 445 State St., North Haven, Conn.

FRIEDMAN, WALTER F., Sales Engineer, General Gummed Products, Inc., 126-15 Eighty-ninth Ave., Richmond Hill 18, N. Y.

LAWATSCH, FRANK E., Industrial Div., The De Laval Separator Co., Poughkeepsie, N. Y.

KELLIS, GEORGE E., Chief Industrial Lubrication Engineer, Sinclair Refining Co., 600 Fifth Ave., New York 20, N. Y.

RAVICH, LEONARD E., Director of Research, Vat-Craft Corp., 547 W. 110th St., New York 25, N. Y.

RICHMOND, WILLIAM W., Sales Engineer, National Lead Co., 111 Broadway, New York, N. Y. For mail: 47 Bay Ave., Huntington, N. Y.

WILLIAMS, BEN W., Technical Assistant, International Business Machines, Dept. 800, Plant 2, Poughkeepsie, N. Y.

VANNUCCI, ACHILLE, Chief, Technical Liaison Office, AERFER. For mail: Republic Aviation Corp., Farmingdale, L. I., N. Y.

Ohio Valley District

CARLSON, THEODORE H., Assistant Plant Metallurgist, Bridgeport Brass Co., S. Holt Rd., Indianapolis, Ind.

Philadelphia District

FIKENTSCHER, ALFRED W., Alcar Builders Specialties, Inc., 1315 Buttonwood St., Philadelphia 23, Pa.

GILBERT, G. L., JR., American Twine and Fabric Corp., 82 Congress St., Portsmouth, N. H. For mail: 941 Drexel Bldg., Philadelphia 6, Pa.

MINELLI, JOHN J., Quality Control Director, Eureka Specialty Printing Co., 530 Scranton, Pa.

PHILADELPHIA NAVAL SHIPYARD, Commander, U. S. Naval Base, Philadelphia 12, Pa.

Pittsburgh District

LIBBEY-OWENS-FORD GLASS CO., H. A. Fox, Technical Manager, Parkersburg, W. Va.

CAMERON, JOSEPH A., Assistant Chief Metallurgist, Elliott Co., Jeannette, Pa.

WHEELER, HARVEY B., Manager Laboratory Services Dept., The Neville Co., Neville Island, Pittsburgh 25, Pa.

Southern California District

CONAWAY, WALTER D., Head of Quality Control, Robertshaw-Fulton Controls, Anaheim Div., Santa Ana Freeway at Euclid, Anaheim, Calif. For mail: 5851 Briercrest, Bellflower, Calif.

Washington (D. C.) District

GILES, JAMES H., JR., Materials Engineer, National Bureau of Standards, Washington 25, D. C. For mail: 5516 Thirty-ninth St., N. W., Washington, D. C.

TRAVER, ROY F., Assistant Chief Chemist, Camp Manufacturing Co., Franklin, Va.

U. S. and Possessions

ABER CO., INC., THE, D. R. Armstrong, Secretary-Treasurer, Box 1002, Houston, Tex.

ADAMS, CLEVELAND L., Head, School of Textile Technology, Textile Bldg., Auburn, Ala.

CLARK, WARREN W., Partner, Clark & Groff, Engineers, 3245 South Commerical St., Salem, Ore.

CORDON, WILLIAM A., Materials Engineer, U. S. Bureau of Reclamation, Denver Federal Center, Denver, Colo. For mail: 1600 Trenton St., Denver 8, Colo.

GADDY, JOHN WILLIAM, Superintendent, Charles H. Tompkins Co., 907 Sixteenth St., N. W., Washington, D. C. For mail: Box 2055, Tullahoma, Tenn.

TENNESSEE HIGHWAY RESEARCH PROGRAM, University of Tennessee, Engineering Experiment Station, Knoxville 16, Tenn.

Other than U. S. Possessions

ASSOCIATION DES INDUSTRIELS DE BELGIQUE, Y. Verwilst, General Manager, 29 Avenue André Drouart, Brussels, Belgium.

BEYER, ARTUR, Manager, Fachausschuss Mineralölnormung, Alsterufer 4-5, Hamburg 36, Germany.

HUGGENBERGER, O. R., Manager, Mechanical Development Dept., Dominion Rubber Co., Ltd., Box 330, Place D'Armes, Montreal, P. Q., Canada.

GOTTFELD, F. H., Manager, Solus-Schall Ltd., 18 New Cavendish St., London W.1., England.

PIRANI, ROBERTO, Research Chemist, Montecatini Soc. Gen., Ufficio Brevetti, via F. Turati 18, Milan, Italy.

SILVA CALDERON, L. J., Mechanical Engineer, C. A. Venezolana de Cementos, Edif. Gradillas, 3er piso 33, Caracas, Venezuela. For mail: Apartado 2036, Caracas, Venezuela.

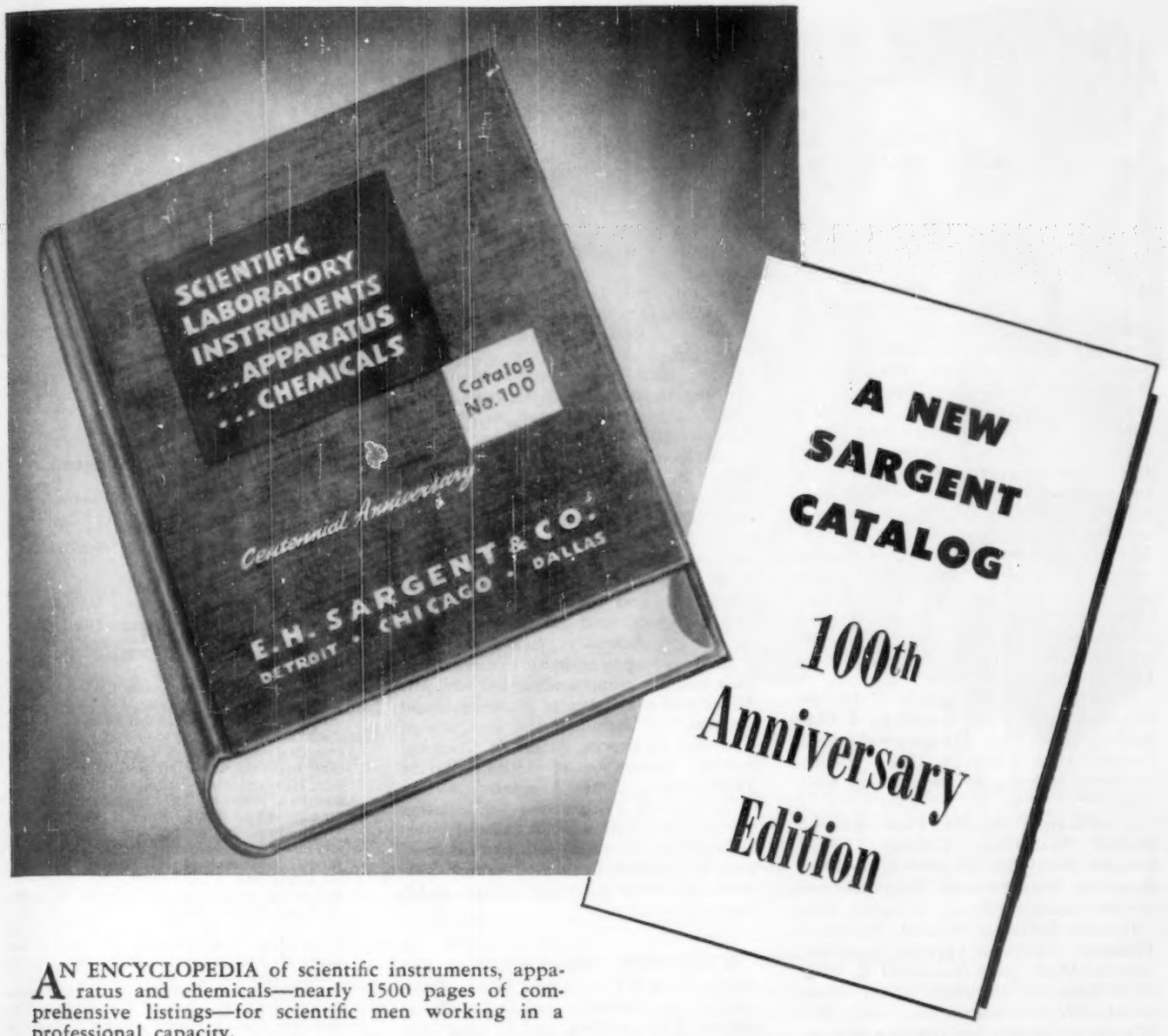
SOLER, SALVADOR LLUCH, Jefedel Laboratorio de Ensaye, Universidad Católica de Chile, Santiago, Chile.

SOUTH AFRICAN AIRWAYS, Chief Superintendent, Rand Airport, Germiston, Transvaal, South Africa.

STAATLICHES MATERIALPRÜFUNGSAMT NORDRHEIN-WESTFALEN, Wilhelm Bischof, Ltd. Regierungsdirektor, Marsbruchstrasse 186, Dortmund, Aplerbeck, Germany.

VARGAS VILLATE, JOSE A., Civil Engineer, División de Suelos y Pavimentos para Aeropuertos y Carreteras, Laboratorio de Ensayos del Ministerio de Obras Públicas, San Jose, Costa Rica. For mail: Calle 6, Avenidas 3 y 5, No. 308, San Jose, Costa Rica. [J]*

* [J] denotes Junior Member.



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NECROLOGY...

The death of the following members has been reported

ARTHUR L. ABBOTT, Rutherford, N. J. (July 26, 1952). Member of the staff of the National Electrical Manufacturers Assn., New York City, since 1931, and previously Technical Director, Electragist Assn., Electrical Contractors Assn., also for many years electrical contracting engineer in St. Paul, Minn. Author of the National Electrical Code Handbook, and the Electrical Contractors Estimating Manual, Mr. Abbott also contributed many articles to leading technical publications. He was a prime mover in the development of standards for electrical estimating now widely used in the electrical construction industry. In ASTM Mr. Abbott represented NEMA for many years on a number of the technical groups including Committees A-1 on Steel, A-3 on Cast Iron, A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys, B-2 on Non-Ferrous Metals and Alloys, and D-20 on Plastics.

OTTO E. HAGER, Engineer of Bridges and Structures, The Chesapeake & Ohio Railway Co., Pere Marquette District, Detroit, Mich. (July 14, 1952). Representative of company membership since 1949.

J. STROTHER MILLER, Consultant on Asphalt Technology, Rahway, N. J. (August 23, 1952). Member since 1903; Honorary Member since 1946. (See accompanying article.)

HARVEY WHIPPLE (retired), Secretary-Treasurer, American Concrete Institute, Detroit, Mich., died September 6, 1952, at his home in Northville, Mich. Associated with the Institute since 1919, Mr. Whipple previously had served a number of years with the *Detroit Free Press* and *Detroit News* and as managing editor of *Concrete-Cement Age*. When he came to ACI as part-time secretary in 1919 the Institute membership was 232. His intense interest in ACI affairs soon induced him to devote full time to them and through his continued efforts membership was in excess of 5800 at the time of his death. In 1921 he assumed the responsibilities of Institute treasurer and filled the dual role until this year when he was named editorial consultant upon his retirement July 1. Mr. Whipple inaugurated the ACI *News Letter* in 1920 which became part of the *Journal* of the American Concrete Institute when that technical periodical was begun under his guidance in 1929. For 23 years the *Journal* has published the results of research, design, and construction activities of many of the experts in these phases of concrete work, becoming a recognized authority in this field. In ASTM Mr. Whipple had represented the Institute through the years in many of the groups concerned with cementitious materials, and had cooperated closely in ASTM activities.

John Strother Miller

1876–1952

IN HIS fiftieth year of ASTM membership, J. Strother Miller, leader in the asphalt technology field, and important contributor to the work of the Society, died at his home in Rahway, N. J., on Saturday, August 23. Born in Washington, D. C., Mr. Miller, following graduation from Cornell University, was in his early years in governmental employ, for a time with the Laboratory, Supervising Architect's Office, and later with the Technologic Branch, Geological Survey, in Washington. From 1909 until his retirement in 1942, he was associated with the Barber Asphalt Corp., Barber, N. J., joining the technical staff as Principal Assistant Chemist, and becoming Director of the company's Technical Bureau in 1926. In more recent years and until the time of his death he had been affiliated with Miller-Warden Associates, Swarthmore, Pa., consultants concerned with problems relating to asphalt technology, product development, marketing analyses, bituminous and concrete paving, structural concrete, and allied subjects. A specialist in chemistry, physics, and engineering relating to asphaltic hydrocarbons, their refining, compounding and use, Mr. Miller was a member of many technical organizations including the Institute of Chemical Engineers, American Chemical Society, Association of Asphalt Paving Technologists, and American Society of Municipal Engineers—participating through the years in national and international discussions on standardization of tests for emulsified asphalts for road purposes, and other important matters in his field.

In ASTM Mr. Miller's activities were concentrated in Committees D-4 on Road and Paving Materials, and D-8 on Bituminous Waterproofing and Roofing Materials; he served as chairman of the latter group 1944–1950. His first contacts with ASTM work, however, were in connection with his service on Committees C-1 on Cement, and D-1 on Paint, Varnish, Lacquer and Related Products. He conducted the cooperative physical tests and chemical analyses upon which the original methods for testing portland cements were based, and was active in the early development work of Committee D-1, in particular that relating to the Havre de Grace paint exposure tests. In recognition of his many and varied contributions ASTM accorded him its highest honor in 1946 when he was elected to Honorary Membership.

Respected and liked by his friends and associates in the Society, as well as in industry generally, "Strother," as he was known to so many, will be missed by those who worked closely with him. As aptly put by one of his immediate coworkers, "his fine reputation stands as a lasting tribute to his many contributions to asphalt technology and to his very full and useful life as a real gentleman."

Townsend to Continue as ODM Adviser

JOHN R. TOWNSEND, Past-President of ASTM and Director of Materials Applications Engineering, Bell Telephone Laboratories, Inc., has recently concluded a nine-month assignment as Consultant to the Director of the Office of Defense Mobilization on Conservation.

The conclusion of Mr. Townsend's participation in the work of the Office of Defense Mobilization will not bring to a close his services to this Office for he has consented to continue as adviser in conservation problems.

Calendar of other Society Events

"Long" and "short" calendars will appear in alternate BULLETINS. The "short" calendar notes meetings in the few immediate weeks ahead—the "long" calendar for months ahead.

NATIONAL LUBRICATING GREASE INSTITUTE—Annual Meeting, Oct. 27–29, Edgewater Beach Hotel, Chicago, Ill.

ELECTROCHEM SOCIETY, INC.—Oct. 27–31, Fall Meeting, Mt. Royal Hotel, Montreal, Canada.

ASSOCIATION OF CONSULTING CHEMISTS AND CHEMICAL ENGINEERS, INC.—Oct. 28, Annual Symposium, Hotel Belmont Plaza, New York, N. Y.

AMERICAN CHEMICAL SOCIETY—Oct. 29–31, Fall Meeting, Division of Rubber Chemistry, Hotel Statler, Buffalo, N. Y.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Oct. 30–31, Fuels 15th National Conference, Phila., Pa.

SOCIETY OF AUTOMOTIVE ENGINEERS—Oct. 30–31, National Diesel Engine Meeting, St. Louis, Mo.

SOCIETY OF CHEMICAL INDUSTRY—Oct. 31, Waldorf-Astoria Hotel, New York, N. Y.

SCIENTIFIC APPARATUS MAKERS ASSOCIATION—Nov. 5–9, Midyear Meeting of Industrial Instrument, Laboratory Apparatus, Laboratory Equipment, Optical Aeronautical and Military Instruments Sections, The Homestead, Hot Springs, Va.

AMERICAN ASSOCIATION TEXTILE CHEMISTS AND COLORISTS—Nov. 6–8, National Convention, Boston, Mass.

ELECTRON MICROSCOPE SOCIETY OF AMERICA—Nov. 6–8, Annual Meeting, Statler Hotel, Cleveland, Ohio.

AMERICAN PETROLEUM INSTITUTE—Nov. 10–13, 32nd Annual Meeting, Conrad Hilton Hotel and Palmer House, Chicago, Ill.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS—Nov. 12–15, 60th Annual Meeting, Waldorf-Astoria, New York, N. Y.

NATIONAL PAINT, VARNISH AND LACQUER ASSOCIATION—Nov. 17–19, Palmer House, Chicago, Ill.

AMERICAN STANDARDS ASSOCIATION—Nov. 19, 34th Annual Meeting, Waldorf-Astoria, New York, N. Y.

FEDERATION OF PAINT AND VARNISH PRODUCTION CLUBS—Nov. 20–22, 30th Annual Meeting, Palmer House, Chicago, Ill.

MANUFACTURING CHEMISTS' ASSOCIATION—Nov. 25, 2nd Semi-annual Meeting and Winter Conference, Hotel Statler, New York, N. Y.

AMERICAN PHYSICS SOCIETY—Nov. 28–29, Washington University, St. Louis, Mo.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Nov. 30–Dec. 5, Annual Meeting, Statler Hotel, New York, N. Y.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS—Dec. 7–10, Annual Meeting, Cleveland and Carter Hotels, Cleveland, Ohio.

AMERICAN ASSOCIATION ADVANCEMENT OF SCIENCE—Dec. 26–31, Annual Meeting, St. Louis, Mo.

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YOU can depend on the Instron Electronic Tensile Testing Instrument for *accuracy*. In this self-contained, electronically controlled instrument you get accuracy heretofore unobtainable over a wide field of test and load conditions . . . from 2 grams to 1000 pounds full scale at speeds of 0.2 to 20 inches per minute. Other models handle loads to 5000 pounds.

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You can accurately measure and record the properties of textile fibers, yarns and fabrics, plastic materials, rubber, paper, leather and adhesives. The Instron Tensile Testing Instrument is well suited for the field of fine wires and metallurgical research. It is particularly useful in those special applications where the magnitude and shape of the quick variations in load are especially important and can be detected only in a *low inertia system.*

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Instron has a sensitive electronic weighing system for detecting and recording the load applied to the sample under test. Pulling jaw is operated by a unique drive that provides an absolutely controlled rate of elongation of the sample over a wide range of speeds, in either direction of travel, and with instant reversibility. The chart of the high-speed recorder is driven at various speed ratios with respect to the pulling jaw, so that tensile load-elongation curves of the material are made accurately, over a wide range of magnifications.

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The versatility of the controls of the Instron Tensile Testing Instrument, both for changing the sensitivity of the load recording system and for operating the motion of the pulling jaw, open an unlimited variety of testing techniques for the determination of special properties.

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Accessories include Jaws, Compression Testing Attachments, and an Automatic Integrator for evaluating the area of load deformation curves.

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NEWS NOTES ON

Laboratory Supplies and Testing Equipment

Instrument Notes

Chemical Proportioning Pumps—Displacement of all liquid in the cylinder at every stroke, with stroke adjustable while the pump is running, is stated as a feature of a new chemical proportioning pump recently announced. Other features are: both the stroke adjustment mechanism and the legible indicating scale are stationary while the pump is running; the piston is reciprocated by a positive mechanical linkage to the crank arm (it does not rely on a return spring); check valves can be removed easily for cleaning or replacement; powered by Class I, Group D, explosion-proof motors.

American Instrument Co., Inc., Silver Spring, Md.

New Universal Testing Machine—A new type of universal testing machine, incorporating an electric weighing system and electronically controlled, motor-driven loading mechanism, is announced. The new unit, called the "Model FGT Baldwin-Emery SR-4" testing machine has a capacity of 50,000-lb load and is said to embrace all of the following characteristics: (1) Weighting and measuring tolerances of 0.2 per cent of reading. (2) High-speed response of indicator or recorder to dynamic as well as static loads. (3) Extreme structural stiffness and lateral rigidity. (4) Wide range of loading speeds under precise stepless control. (Standard loading speed is 0.025 to 9.0 in. per min.) (5) Automatic load control for maintaining (*a*) constant load, (*b*) constant strain, (*c*) constant rate of loading, or (*d*) constant strain rate, thus enabling determination of creep, rupture, and relaxation properties of materials. (6) Single convenient location for test specimens in both tension and compression tests. (7) Automatic reversals of load, that is, tension to compression to tension. (8) Quick-acting, semi-automatic operation for "production testing." Printing of critical test values included when desired. (9) Adaptability to stress analysis of parts and components of structures on which SR-4 strain gages or brittle coating techniques are utilized. Bulletin 4202 describes the unit.

Baldwin-Lima-Hamilton Corp., Paschall Station P.O., Phila. 42, Pa.

Oxidation Unit—A new instrument created for the rubber and plastics industry is said to permit the precise determination of the amount of oxygen absorbed by rubber, plastics, fibers, or other materials which are subject to deterioration on exposure to air or oxygen. The design of the unit is based on the volumetric oxygen-absorption method, developed originally by J. R. Shelton and co-workers at Case Institute of Technology, for oxidation and aging studies on rubber and related materials. The method is said to be useful both for routine aging tests and for fundamental studies on the mechanism of the oxidation reaction. Literature available.

G. F. Bush Associates, Box 175, Princeton, N. J.

Spring Tester—Loads and deflections of small compression and extension springs are accurately measured by this precision spring tester having a load range capacity from ½ oz to 25 lb. The scale is said to be accurate to within ¼ of 1 per cent, meeting the requirements of the National Bureau of Standards. Steel rules measure lengths in 32nds and 64ths on one side and in decimals in 10ths and 100ths on reverse side. A 1-in.-capacity dial indicator measuring lengths and deflections to 0.001 in. is available. Adaptable for both general purpose and high quantity production testing, the speed of testing varies from 250 to 500 tests per hr. Production stops and tolerance markers are easily adjustable. Springs with diameters up to 2 in. and lengths up to 10 in. can be tested. Descriptive bulletin available.

The Carlson Co., 277 Broadway, New York 7, N. Y.

Infrared Film—A new film is described as having a total "red speed" greater than any other material on the market. The company states that in tests conducted at the University of Rochester, successful motion pictures were made of audience reactions when house lights in a theater were dimmed to $\frac{1}{10}$th of normal room illumination. The new film can be used in any standard 16 or 35-mm motion picture camera accepting roll film or 16-mm magazines. Known as Kodak Spectroscopic I-N Film, the new film was originally intended for use by spectrographic laboratories. It is now, however, being used for many other purposes where its sensitivity to the infrared range of the spectrum makes it particularly valuable for recording—without supplemental illumination—the flow and action of molten or hot metals.

Eastman Kodak Co., Rochester 4, N. Y.

Flash Point Equipment—Fisher Scientific Co. announces that it has completely redesigned three flash point testers. They are the gas model and two electric models of the Fisher/TAG Cleveland Open Cup Flash and Fire Point Testers. Each of the new models is designed and constructed to meet the ASTM specifications for determining flash and fire points as given in ASTM Standard Method D 92.[1] Choice of model and means of heating depend upon the analyst's preference. Each of the new models of the Cleveland Open Cup Testers has been redesigned as a unit to make it easier to move from one laboratory to another. Gas and electric heaters are now integral parts of the stand assembly, with gas inlet on both type models mounted in the rear at the bottom of the stand. Just one short piece of rubber tubing connects the gas inlet to the bench gas tap.

[1] "Method of Test for Flash and Fire Points by Means of Open Cup," (D 92 – 46), 1949 Book of ASTM Standards, Part 3, p. 1067, Part 5, p. 716.

A new rigid assembly of the test flame torch and its own individual pilot light is mounted in a convenient position on the heater of the gas-heated model. On this model there is no rubber or flexible tubing to twist, burn, or come off. This is said to eliminate the possibility of burnt fingers. Also in the gas-heated model a smaller grid has been substituted in the burner so that the flame will not backfire at the slow ASTM heating rate (to be adjusted to 9 to 11 F per minute by the operator). Each electric model is heated with a resistance-type heater controlled with a variable autotransformer for precision adjustment of the heating rate. The redesigned handle is now made of stainless steel tubing to reduce the amount of heat conducted from the hot cup to the grip. This new design should result in longer life for the wooden grip by reducing charring and loosening. An adjustable test flame torch, pivoted in a special clamp, is provided in both electric and gas models for swinging the test flame across the center of the cup at the distance from the surface of the sample specified by ASTM. The Fisher/-TAG Cleveland Open Cup Flash Tester, electrical model "A," uses 115 v, 50–60 cycle ac; model "B" uses 230 v, 50-60 cycle ac. Both come with ASTM thermometers. The gas-heated model uses either artificial or natural gas.

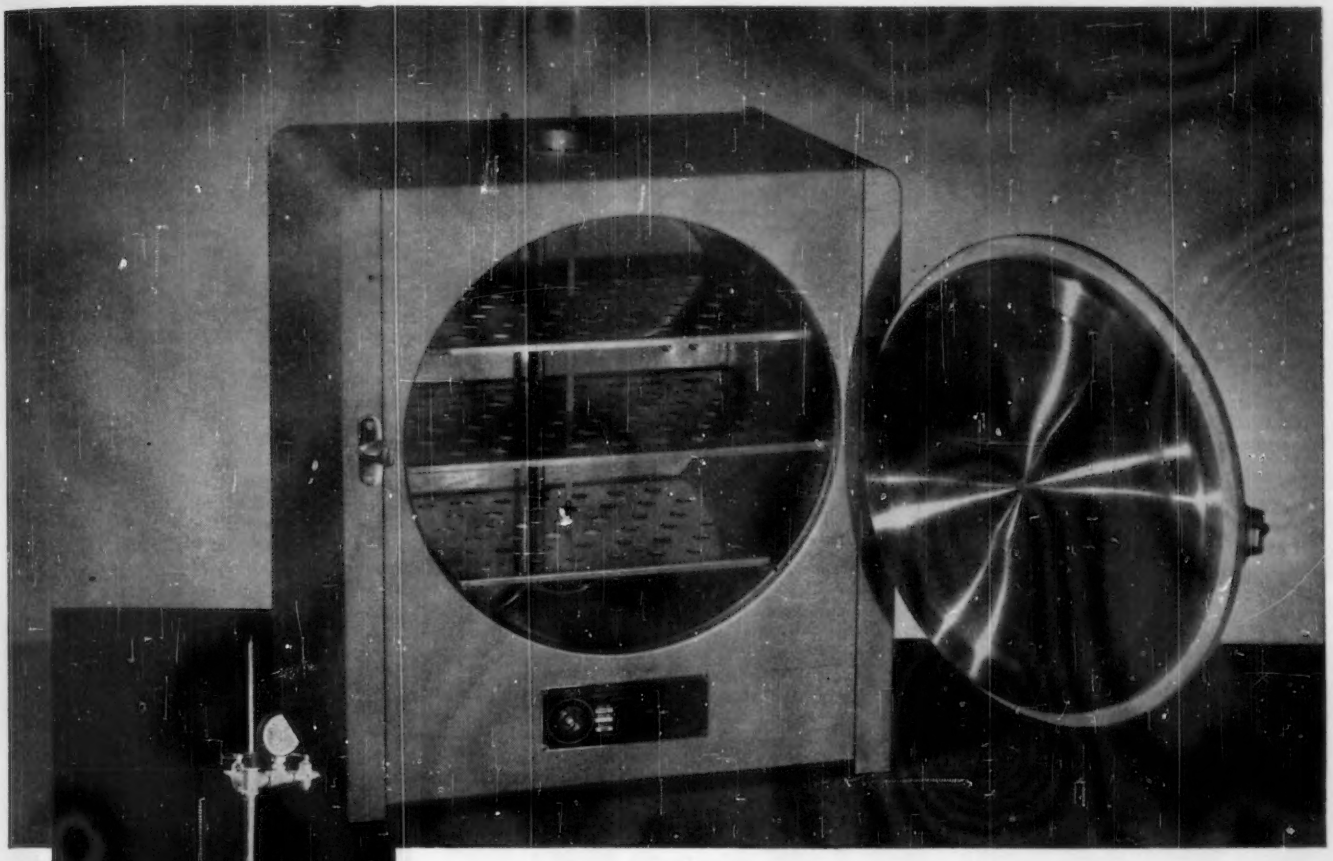
Fisher Scientific Co., 717 Forbes St., Pittsburgh 99, Pa.

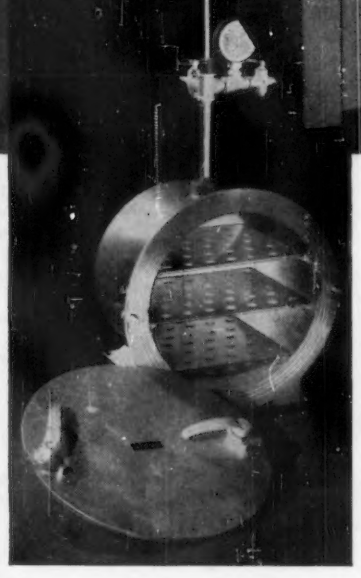
Large Area Colorimeter—A new large-area color and color difference meter has just been completed by the Garner Laboratory in fulfillment of a special requirement for an instrument which will satisfactorily measure the color of fabric samples that have been laundered. It is essential that a large area be measured, since the towels, sheets, shirts, etc., being tested are soiled in a non-uniform manner. The design of the new instrument is based on the Gardner Laboratory's Color and Color Difference Meter, the major alteration being in the size of the sample exposure head. The new instrument is said to be suitable for the measurement of color changes from clean fabric—to soiled—to laundered, thus showing the effectiveness of the detergent under test. The instrument's large 9 by 12-in. exposure area allows accurate measurement in spite of the non-uniformity of the soil on the samples, it is claimed.

Gardner Laboratory, Inc., Bethesda 14, Md.

Multi-Purpose Magnetic Probe—A new, powerful, magnetic probe is said to be particularly useful for removing steel or iron particles from areas where such foreign matter is harmful, such as the operating area of electrical instruments or delicate mechanisms. It will also conveniently remove sharp particles of steel, iron, or nickel from storage bins and retrieve magnetic particles from holes and similar hard-to-reach places. Assemblers and inspectors are said to find the probe useful to test coat of surfaces for magnetic

(*Continued on page 74*)





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(*Continued from page 72*)

properties of the under-material. The new magnetic probe, made of super-magnetic alloy, is no larger than a fountain pen. Point of magnet is extended or retracted from a case by turning end-knob.

General Scientific Equipment Co., 2700 W. Huntingdon St., Phila. 32, Pa.

G-Accelerator—Genisco, Inc., announces that a Model "C" G-Accelerator has been added to its line of testing devices. The new 8-ft-diameter model is similar in arrangement and operation to the smaller 56-in.-diameter Model "B" and incorporates optical, pneumatic, and electrical systems combined for testing aircraft and guided missile components of a larger size than heretofore possible.

The device applies a steady force of controlled magnitude to parts or assemblies for calibration or for observing functional behavior under simulated operating conditions. The object to be tested is secured to either of the two symmetrical mounting platforms on the rotating arm, and the arm is balanced by securing a similar mass on the opposite end. Electrical leads and air connections are carried to the mounting platform through slip rings and a rotary air gland. The test object can be seen as though stationary, regardless of rotational speed, through a telescopic optical system, permitting close observations of the part at any time during testing.

Genisco, Inc., Dept. AB, 2233 Federal Ave., Los Angeles 64, Calif.

Short Cycle Process Controller—A short-cycle time-proportioning relay has been developed for controlling nylon heat setting, linoleum curing, and metallurgical and laboratory-size furnace testing. The newly developed model has been added to the "Electr-O-Pulse" relay line of the Industrial Division of Minneapolis-Honeywell Regulator Co. to meet an increase in the number of processes having short time lags. Such processes, it was said, demand a pulse-type relay with a short cycle time for which the new model has proved effective in field tests.

Minneapolis-Honeywell Regulator Co., Industrial Division, Wayne & Windrim Aves., Phila. 44, Pa.

New Impact Tester—A new three-capacity-range Impact Tester especially designed for testing plastics, ceramics, and light metals is now available. It was developed to provide a wider capacity range in making standard tests of plastics and electrical insulating materials. Accuracy is said to rigidly conform to Federal Specification L.P. 406a and ASTM Method D 256.[2] A maximum of clearance and open working space around the specimen rest and vise is provided. This makes for convenience, especially in making tests at subnormal or super-normal temperatures, when it is desirable to locate the specimen refrigerator or oven adjacent to or surrounding the specimen holders. The machine makes either the Izod (cantilever beam) or Charpy (simple beam) test on each of its three capacity ranges. A separate hammer is provided for each of these tests in each capacity range, that is, six hammers in all. The hammers are quickly and conveniently interchangeable, being firmly secured to the ball-bearing spindle by two hardened screws. Calibration of the hammers as regards static weight, balance, and concentration of mass at the striking point is done individually. Each hammer is one welded or riveted unit with the striking bit a permanently integral part. The possibility of variable errors due to energy absorption by screwed-on weights and detachable bits is eliminated.

National Forge and Ordnance Co., Testing Machine Div., Irvine, Warren Co., Pa.

Scaler-Printer for High Speed Counting—A new scaler-printer designed for radiation counting as applied in nuclear work, packaging, and other applications, has been announced. The instrument indicates in printed numerals up to 999 and provides for multiplying this figure by 2, 4, 8, 16, 32, and 64. It is said to resolve pulses separated by 5 microseconds and to perform reliably for indefinite periods of time. An interval timer having a range up to 55 sec allows count accumulation for a predetermined interval, reproducible to within 0.13 second.

North American Philips Co., Inc., 750 S. Fulton Ave., Mount Vernon, N. Y.

Torque Balance—A line of precision torque balances manufactured in Holland, has recently been introduced in the United States by the Ohaus Scale Corp. These balances feature a patented torsion system which eliminates mechanical axle friction. They are particularly suitable for use where a large number of accurate weighings must be done. The rapidity of weighing is increased by a special damping device which does not affect the sensitivity of the balance. There are models available in capacities from 1 mg to 20 g with sensitivities ranging from 0.002 to 0.02 mg. These balances find use in the pharmaceutical, electronic, and process industires, however, their use is said to be by no means restricted to these fields. The balances are said to incorporate: fine sensitivity, eye level reading, resistance to shock, attractive stand enabling specific gravity weighing, and easy reading device without cumbersome vernier.

Ohaus Scale Corp., 1050 Commerce Ave., Union, N. J.

Portable Pyrometer and Millivoltmeter—Designed for portability to the job and with a high degree of accuracy, a new combination temperature indicating pyrometer and millivoltmeter is now available. Long thermocouple leads permit temperature checkings up to 8 ft from the instrument and in places not readily accessible. Three scale ranges are available, all calibrated in Fahrenheit, Centigrade and Millivolts, as follows: 800 F—430 C—17 mv; 1600 F—865 C—36 mv; 2250 F—1225 C—50 mv.

Thermo Electric Mfg. Co., 480 Huff St. Dubuque, Iowa.

Research Electromagnet—Magnetic fields as high as 40,000 gauss, or lower fields with extremely high uniformity are said to be provided by the new Model V-4012 Varian Research Magnet. Applications include nuclear and paramagnetic resonance work, Zeeman studies, and other research projects where relatively high volumes of high homogeneity magnetic field are required. Under the standard arrangement with pole caps of 12 in. diameter and air gap of $1\frac{3}{4}$ in., a magnetic field is produced which is said to be uniform to one part in 50,0000 throughout a cubic inch volume of air gap. Maximum air gap of $5\frac{1}{4}$ in. is possible. For high-field studies tapered pole caps are substituted for the conventional flat ones.

Varian Associates, 957 Varian St., San Carlos, Calif.

Test Chamber—A recent development in testing equipment is the Webber Test Chamber for production line and experimental testing. Combining high temperature, low temperature, and humidity, this unit has a temperature range from +250 to −100 F. Accelerated pull-down is one of the features offered in this unit which can be cycled from ambient to −100 F in 45 min and can be cycled from −100 to +200 F in 30 min. Both high and low temperatures are governed by a temperature controller with a scale range from −200 to +400 F with a three degree control point differential, $\pm 1\frac{1}{2}$ deg. The humidity is regulated by a wet and dry bulb controller which provides 95 per cent relative humidity at temperatures between 75 and 95 F. Vacuum equipment can be added to simulate high altitude conditions. The test chamber is $4\frac{1}{2}$ cu ft, 20 in. high, 20 in. wide, and 20 in. deep. Model A-$4\frac{1}{2}$-100FHH.

Webber Appliance Co., Inc., Industrial Freezer Div., 2740 Madison Ave., Indianapolis 3, Ind.

Catalogs and Literature

Coating Thickness Instrument—A six-page folder describing theory and operation of the "Coatingage" Model 600 has been released by Branson Instruments, Inc. This portable instrument is used to measure the thickness of nonmagnetic coatings on magnetic bases, and to detect pin-holes in nonconductive coatings on conductive bases. One of the most important applications for the instrument is said to have been the examination of corrosion-protective coatings for thickness and film continuity.

Branson Instruments, Inc., 430 Fairfield Ave., Stamford, Conn.

Soil Resistivity Apparatus—A new data sheet is available on the "Collins Single Rod Soil Resistivity Apparatus." This equipment is said to measure accurately electrical resistivity of soils, waters, emulsions, etc., up to 50,000 ohm-cm.

J. L. Collins, Angleton, Tex.

Halogen-Sensitive Leak Detector—A new data sheet describing the Halogen-Sensitive Leak Detector, Type LD-01, produced by Distillation Products Industires, a division of Eastman Kodak Co., has just been produced by the company. The instrument reveals leaks in high vacuum systems by responding to small traces of probe gases, generally halogen-bearing compounds such as Freon gas, which are sprayed externally at suspected leakage points. It is designed as an aid in maintaining high vacuum systems at top operating efficiency.

Vacuum Equipment Dept., Distillation Products Industries, Rochester 3, N. Y.

Turbidity Recorder—Another bulletin, of the photo-electric eye series, is now made available by the Ess Instrument Co. The new bulletin covers the Turbidity Recorder TR-6, an instrument for measuring the amount of light cut off by undissolved substances suspended in fluids. Pertinent information relative to operating principles, and range of application of the instrument to processing or sampling line, is included with technical sketches illus-

(*Continued on page 76*)

[2] "Tentative Methods of Test for Impact Resistance of Plastics and Electrical Insulating Materials" (D 256 – 47 T), 1949 Book of ASTM Standards, Part 6, p. 131.